YEARLY SUBSCRIPTION, $6.00 SINGLE NUMBERS $1.00

Medical Lib

THE AMERICAN JOURNAL OF ROENTGENOLOGY

[FOUNDED IN 1906 AS THE AMERICAN QUARTERLY OF ROENTGENOLOGY]

OFFICIAL ORGAN OF
THE AMERICAN ROENTGEN RAY SOCIETY
AND THE AMERICAN RADIUM SOCIETY

Editor: H. M. IMBODEN, M.D.

Associate Editors:
JAMES T. CASE, M.D. H. K. PANCOAST, M.D. J. S. SHEARER, PH.D.

EDITORIAL BOARD

FREDERICK H. BAETJER, M.D.
A. BECLERE, M.D.
DAVID R. BOWEN, M.D.
PERCY BROWN, M.D.
R. D. CARMAN, M.D.
L. G. COLE, M.D.
A. W. CRANE, M.D.
A. W. GEORGE, M.D.
PRESTON M. HICKEY, M.D.
ROBERT KNOX, M.D.
R. LEDOUX-LEBARD, M.D.
G. E. PFAHLER, M.D.
A. H. PIRIE, M.D.
E. H. SKINNER, M.D.

VOLUME IX NUMBER 2

February, 1922

PUBLISHED MONTHLY BY PAUL B. HOEBER
NEW YORK CITY

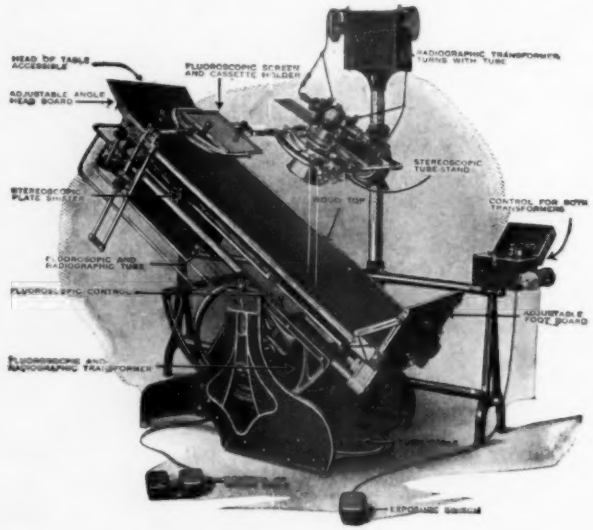
Entered as second-class matter, March 3, 1916, at the Post Office, New York, N. Y., under the Act of March 3, 1879.

Name.....
Street.....
City.....
State.....
A.
J.
R.

Send Coupon for Catalog giving complete description and a Campbell X-Ray Exposure Scale, Free

Clinix X-Ray Plant

Contrast its Appearance with that of the Old-Style X-Ray Laboratory



The CLINIX is a complete X-Ray plant.

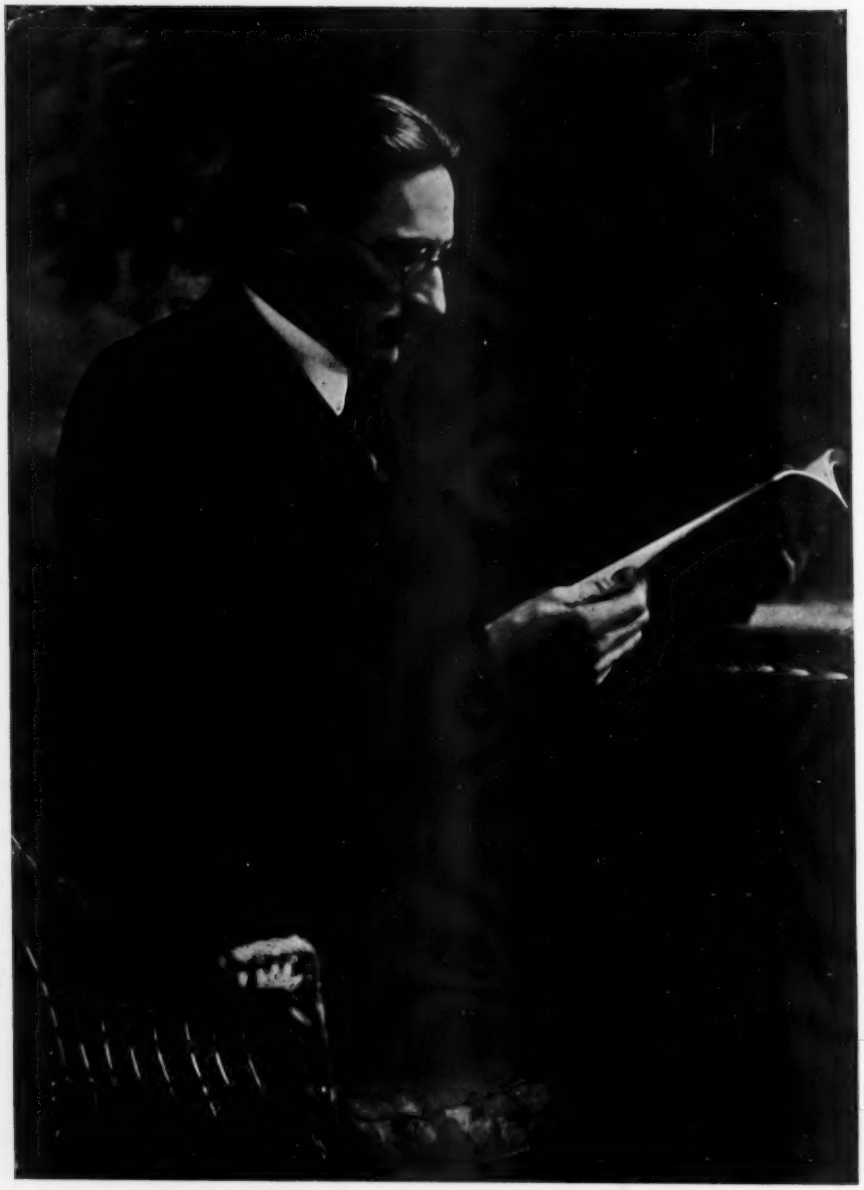
It operates at all angles.

It is the "Aristocrat" of the X-Ray Laboratory.

You owe it to yourself and to your hospital to investigate.

Campbell ELECTRIC CO. LYNN, MASS

U. S. Patents December 19, 1911. April 22, 1913. February 29, 1916. August 7, 1917.
Also patented in foreign countries. Other patents pending. Infringers will be prosecuted.



Jos. G. Van Zwoll Wurmburg

THE AMERICAN JOURNAL OF ROENTGENOLOGY

VOL. IX [NEW SERIES] FEBRUARY, 1922 No. 2

HIGH VOLTAGE X-RAY WORK*

BY W. D. COOLIDGE, PH. D. AND W. K. KEARSLEY, JR.

Research Laboratory, General Electric Company
SCHENECTADY, NEW YORK

CONTENTS

A. INTRODUCTION.
B. DESIGN OF HIGH VOLTAGE *X*-RAY TUBE.
C. DESCRIPTION OF AN EXPERIMENTAL INTERRUPTERLESS MACHINE FOR MORE THAN 300,000 VOLTS (MAX.).
1. The Transformer.
2. The Mechanical Rectifier.
3. Voltage Control.
4. Voltage Measurement.
5. Current Measurement.
6. Circuit-Breaker.
D. DESCRIPTION OF A 200,000 VOLT CONSTANT-POTENTIAL CONTINUOUS-CURRENT MACHINE.
E. MEASUREMENT OF HIGH TENSION VOLTAGE.
F. EFFECT OF ELECTRICAL CHARACTERISTICS OF HIGH TENSION SUPPLY CIRCUIT ON *X*-RAY OUTPUT.
1. Interrupterless Machine, with Resistance vs. Auto-Transformer Control.
2. Interrupterless Machine—Effect of Widely Different Amounts of Ballast Resistance.
3. Interrupterless Machine vs. Induction Coil.
4. Interrupterless Machine vs. Constant-Potential Continuous-Current Machine.
G. EFFECT OF ELECTRICAL CHARACTERISTICS OF HIGH TENSION SUPPLY CIRCUIT ON BEHAVIOR OF *X*-RAY TUBE.
1. Interrupterless Machine, with Resistance vs. Auto-Transformer Control.
2. High Voltage Transformer with No Auxiliary Rectifying Device.
3. Induction Coil.
4. Constant-Potential Continuous-Current Machine.
H. *X*-RAY OUTPUT OF DIFFERENT TUBES OPERATING UNDER THE SAME ELECTRICAL CONDITIONS.
1. Comparison of *X*-Ray Output of 20 High Voltage Tubes Operating at 200,000 Volts (Max.) and 2 ma.
2. Comparison of *X*-Ray Output of 7 Broad Focus Universal Type Tubes Operating at 127,000 Volts (Max.) and 5 ma.
3. Comparison of *X*-Ray Output of 10 Medium Focus Universal Type Tubes Operating at 127,000 Volts (Max.) and 5 ma.
I. LOSS OF *X*-RAY INTENSITY FROM A HEAVY TUNGSTEN DEPOSIT ON BULB.
J. LOSS OF EFFICIENCY FROM THE BAD PITTING OF A TARGET.
K. DISTRIBUTION OF *X*-RAY INTENSITY.
1. Around Girdle of Tube with 200,000 Volts (Max.).
2. In Plane Containing Tube Axis and Perpendicular to Target Face, with 200,000 Volts (Max.).
3. Around Girdle of Tube, with 127,000 Volts (Max.) with Universal Tube No. 22376 and a Similar Tube with a Badly Pitted Target.
4. In Plane Containing Tube Axis and Perpendicular to Target Face, with 127,000 Volts (Max.), with Universal Tube No. 22376, and a Similar Tube with a Badly Pitted Target.
L. ABSORPTION CURVES WITH COPPER FILTERS FOR VOLTAGES UP TO 298,000 (MAX.).
M. GENERAL SUMMARY OF RESULTS.

A. INTRODUCTION

IT seems desirable, for experimental purposes at least, that one should be able to produce *x*-rays of shorter wave-length than those which have heretofore been available. This involves the operation of *x*-ray tubes at very high voltages.

The following is a description of a preliminary survey which we have made up to a voltage of 300,000 (max.). Much of the work has been carried out mainly for the purpose of finding the path of least resistance, as this is the path which should later lead to the successful use of still higher voltages.

It is for most purposes important to know both the intensity and the penetrating power of the radiation, for this reason, other things being equal, preference must be given to that method of production which best lends itself to quantitative control.

As there is an insistent and growing demand for short wave-length radiations

*Read at the Twenty-second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27–30, 1921.

in *x*-ray therapy, the conditions of many of the experiments have been chosen with the medical application in mind.

It is important, especially in the case of the medical application, to know how the measurement of the quantity and quality factors can best be effected, whether through direct measurement of *x*-ray intensity or through electrical measurements of the energy supplied to the tube. It is for this reason that so much attention has been given in the following to the relation between the *x*-ray output and the energy input of the tube. For it is relatively much easier to measure the factors of the energy input, and this is sufficient provided *x*-ray output is determined with sufficient accuracy by electrical input.

B. Design of High Voltage X-Ray Tube

In connection with a paper[1] read before this Society in 1915, a tube was shown which had been operated on an induction coil at the voltage corresponding to a 20 inch spark between points.

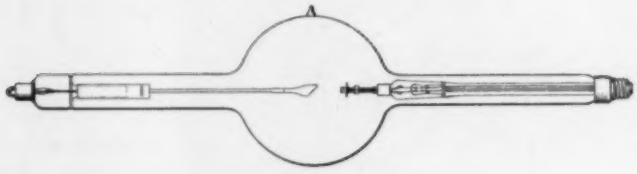


Fig. 1.

The experience gained from working with this and with later experimental models has led to the design shown in Figure 1.

General Description of Model Shown in Figure 1

The bulb is 8 inches in diameter and the overall length is 32 inches. As in the "Universal" type of tube, the anode is of solid tungsten with a molybdenum stem and is supported from almost the extreme end of the anode arm. The distance between the cathode and the anode has been increased from that of the "Universal" type of tube (1 inch) to 2 inches, to reduce the electrostatic pull on the filament and to decrease the tendency for the liberation of electrons from the edges of the focusing device.

Tubes of this design and of the regular "Universal" type have been used for all of the work described in this paper and will be referred to under the names of "High Voltage" and "Universal Type" tubes.

C. Description of an Experimental Interrupterless Machine for more than 300,000 Volts (Max.)

1. The Transformer

Two large transformers, originally intended for electrostatic precipitation work, have been used, with their high tension coils connected in series. The middle point is connected to earth. The low tension coils are connected in parallel.

2. The Mechanical Rectifier

This was of the Snook type and consisted of a wooden shaft, with four metal cross arms, driven by a synchronous motor.

A first model enabled us to go up to 280,000 volts maximum. As some of the *x*-ray tubes would stand more than this, a larger rectifier was built for higher voltage.

There had been one serious difficulty with the first rectifier, namely, that the insulating power of the shaft which was made of wood, had not been high enough. This was remedied in the second one by making the shaft of thin-walled paper-shellac tubing. This does not conduct current, does not warp and has been in every way satisfactory even when handling 300,000 volts during very humid summer weather.

The rectifier cross-arms are 35¼ inches long, and are spaced 33 inches apart. The total length of the rectifier is 12½ feet.

This rectifier has as yet not been operated above 300,000 volts maximum, but is designed for more.

The collectors are large to avoid corona. They consist of brass tubing 3 inches in diameter and are fitted with hemispherical ends. The collectors subtend an angle of 42 degrees of arc.

[1] W. D. Coolidge, "Hard *X*-Rays," Am. J. Roentgenol., 1915.

The gyroscopic action of the cross-arms tends to straighten the shaft out at high speed. This makes it easy to build very large rectifiers of this type.

3. VOLTAGE CONTROL

About four-fifths of the line voltage is consumed in the control resistance. This increases the smoothness of operation of tubes and greatly reduces the danger attendant upon accidental contact with the high tension circuit.

4. VOLTAGE MEASUREMENT

Voltage is measured by means of a voltmeter connected across the low tension side of the *x*-ray transformer. This is calibrated by a sphere-gap connected in parallel with the tube. This gap has spherical electrodes 25 cm. in diameter and conforms fully with the specifications of the American Institute of Electrical Engineers.

5. CURRENT MEASUREMENT

Two milliamperemeters are always connected in series in the *x*-ray tube circuit. This rule was adopted after the following experience: A good milliamperemeter which had just been calibrated was used carefully for two or three days, at the end of which time it was found to be reading over 50 per cent too low. The zero had not changed and up to the time of recalibration there had been nothing to indicate the trouble. Subsequent examination showed that a portion of the resistance shunted around the moving coil had been short-circuited, owing doubtless to a high voltage surge. As there is no known method of providing absolute protection against such surges it would seem best for the therapeutic application of the *x*-rays, always to employ 2 milliamperemeters in the high tension circuit. The probability would be very strong against these two meters ever suffering to exactly the same extent at the same time.

6. CIRCUIT BREAKER

A quick-acting double-pole overload circuit breaker is connected in the primary circuit next to the line. If a current of not more than say 8 ma. is to be used in the tube, the breaker can be adjusted to open the circuit in case the load ever exceeds 10 ma. The presence of a circuit breaker set to open for such a low milliampereage in the high tension circuit, together with the large amount of ballast resistance in the low tension circuit, which prevents the attainment of high instantaneous current values in the high tension circuit, greatly reduces the electrical danger attendant upon the use of such a high voltage outfit.

The heating current for the cathode of the *x*-ray tube has been derived from a storage battery. Otherwise a stabilizer would have been required.

D. Description of a 200,000 Volt Constant-Potential Continuous-Current Machine

A constant-potential continuous-current machine for 200,000 volts is shown diagrammatically in Figure 2.

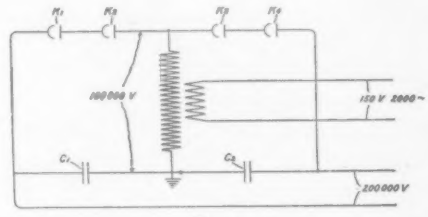


FIG. 2.

Alternating current of 2,000 cycles and 150 volts from a motor-generator set is fed to a special transformer where its voltage is raised to 100,000 (max.). By means of 4 kenotrons K_1, K_2, K_3, and K_4, this alternating current is allowed to flow alternately into two condensers C_1, and C_2. The two condensers are in series and the *x*-ray tube is operated directly from their outer terminals. Each of the condensers has a capacity of 0.001 microfarad. The outfit is seen to be somewhat similar to that described by Dr. Hull.[2]

The necessity for two kenotrons in series in each side of the circuit is due to the fact that the available kenotrons were suitable for only 100,000 volts each and each side of the circuit has to withstand 200,000 volts.

[2] AM. J. ROENTGENOL., 1915, pp. 153–155.

In general, the potential will not divide itself equally between kenotrons. This difficulty is remedied by putting capacity around the kenotron which is getting more than its share of the voltage. This is easily accomplished by first operating the outfit at a voltage which is just sufficient to cause distress in one of the kenotrons. This distress will be manifested by green fluorescence in the bulb. A small amount of capacity is then placed in parallel with this kenotron and this capacity is increased by the cut and dried method until the signs of distress disappear. The voltage of the outfit is then raised. A kenotron on the other side of the circuit may then show distress. It is relieved by connecting capacity in parallel with it. By continuing to raise voltage and adjust capacities, the terminal voltage may be safely brought to 200,000 with the kenotrons showing no distress.

Although some of the relief has been due to leakage as well as capacity, for a period of several months at least, it has not been necessary to readjust the condenser capacity around the kenotrons.

E. Measurement of High Tension Voltage

The measurement of high tension voltage by means of a voltmeter connected across the low tension winding of the transformer or induction coil, may be satisfactorily carried out under certain conditions.

In general, the primary voltage required to produce a given high tension voltage will depend on the milliamperage. It is then necessary to calibrate against the sphere-gap for the exact milliamperage which is to be employed.

This method becomes inaccurate and unsatisfactory in case the voltage varies too rapidly with the milliamperage.

This is illustrated by Table 1, which gives voltage calibrations of four different outfits. For these calibrations the sphere-gap was kept set to spark over on 180 kv. (max.) and, for each tube load, in milliamperes, the voltage impressed upon the low tension winding of the transformer or induction coil was gradually raised until a spark jumped across the sphere-gap.

Table I

Calibration of different outfits at 180 kv. (max.)

Ma.	I Experimental Interrupterless	II Induction Coil	III-A Transformer with Open Magnetic Circuit and Single Arm Switch	III-B Same Transformer as III-A but with 4-arm Rectifier
0	(100)	(100)	(100)	(100)
1	96.0	104.4	137.0	114.0
2	96.6	109.0	169.0	116.0
3	96.6	110.7	217.0	115.0
4	96.6	.....	.....	115.5
5	98.0	.....	.....	108.0

The data of Table 1 are plotted in Figure 3.

In the case of 1, the experimental interrupterless machine (described in Section C), the primary voltage is seen to change very slowly with the load.

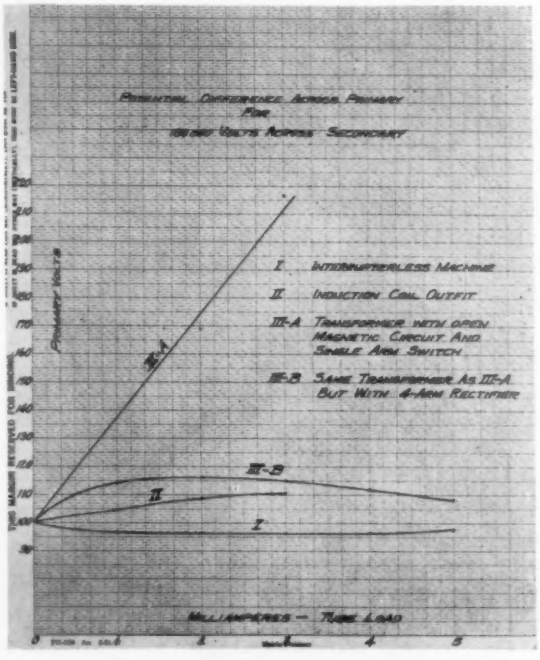

I. Interrupterless Machine
II. Induction Coil Outfit
III-A Transformer with open Magnetic Circuit and Single Arm Switch
III-B Same Transformer as III-A But With 4-Arm Rectifier
III-B
II
I
Milliamperes — Tube Load

Fig. 3.

With 11, the induction coil outfit, the

change is more pronounced, but is still not troublesome.

The outfit III-A, consists of a transformer with an open magnetic circuit, having high magnetic leakage, and a single arm high-tension switch which utilizes every other half wave. The primary voltage curve is seen to rise very rapidly with increasing milliampereage. It rises so rapidly in fact that, for 180,000 volts, the load could not conservatively be increased above 3 ma., because of the danger of breaking down the transformer from the high "inverse" voltage. The worst objection, however, to the use of an outfit having such a calibration curve as III-A lies in the fact that the steepness of the curve reduces the accuracy of measurement of the high tension voltage.

Furthermore, a change of a milliampere or even less in the corona loss would occasion a relatively large error in the voltage determination.

The outfit of the last column, III-B, is the same as III-A except that the single arm high tension switch has been replaced by a 4-arm rectifier. Both half-waves are in this way utilized and the resulting calibration curve is then entirely satisfactory.

F. Effect of Electrical Characteristics of High Tension Supply Circuit on *X*-Ray Output

For this study, the tube was rigidly mounted in front of a lead booth which shielded observer No. 1 and an ionization chamber (Fig. 4). The tube was connected to an overhead aerial system which was 27 feet long and extended into a second, adjoining room. A sphere gap was permanently connected across the aerials and two milliamperemeters were connected in series with the tube. The filament was lighted from a storage battery and the rheostat for controlling the filament current was operated by a cord extending into the lead booth.

It was then possible, at a moment's notice, to connect any one of the high tension generators, referred to in the following, to the aerial system and thence to the tube.

Voltage and milliamperage were both controlled by observer No. 1, while observer No. 2 measured *x*-ray intensity as indicated by ionization currents.

The lead booth was ¼ inch thick on the front (the side facing the tube) and ⅛ inch thick on the remaining five sides. The door

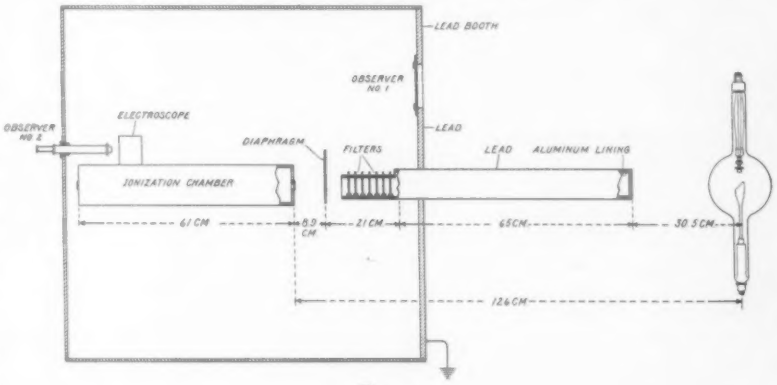


Fig. 4.

was at the back of the booth and was kept closed during the measurements.[3]

The system of diaphragms used to limit the *x*-ray beam was always such as to permit the rays from the entire head of the target to enter the ionization chamber, and care was taken to secure such alignment that none of the beam should touch either

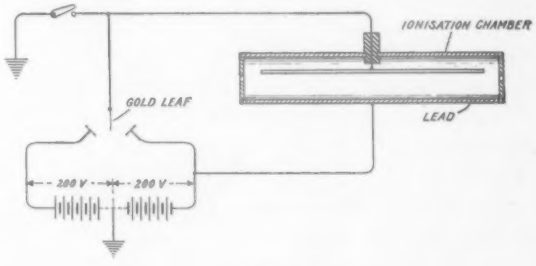


Fig. 5.

of the electrodes of the ionization chamber. The rays entered and emerged from the latter through thin mica windows.

Air at atmospheric pressure was always used in the ionization chamber.

[3] Experiment had shown that this was necessary for the adequate *x*-ray protection of the electroscope.

A Bumstead electroscope was used and was connected to the ionization chamber and dry battery as indicated diagrammatically in Figure 5.

The first experiments were made with an interrupterless machine operating at 127,000 volts (max.), as measured by the sphere-gap.

1. *Interrupterless Machine with Resistance vs. Auto-Transformer Control*

The absorption curves shown in Figure 6 were obtained from ionization chamber measurements, the tube being operated from a Snook direct-current interrupterless machine.

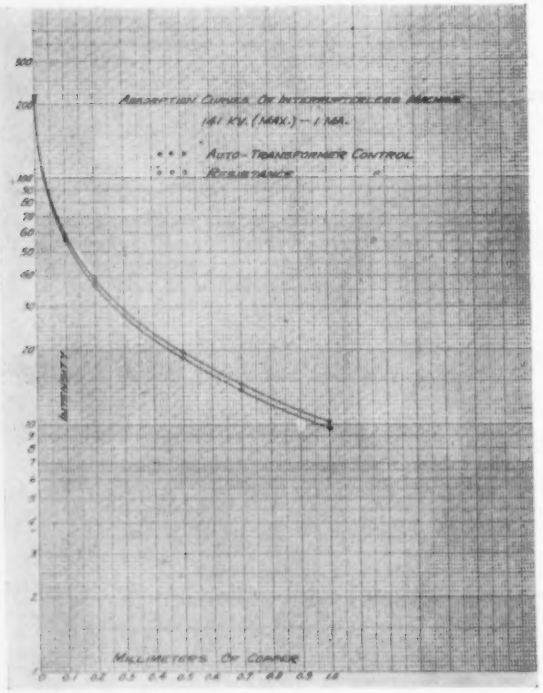


Fig. 6.

The data for these curves is given in Tables II and III.

With both resistance and autotransformer control the fine regulation of voltage was obtained by means of a special 1.5 ohm rheostat inserted in the primary circuit.

In the case of resistance control, the autotransformer was set for maximum voltage, so that as much as possible of the resistance of the control rheostat could be used. Under these conditions 35 per cent of the voltage obtained from the auto-transformer was consumed in the rheostat.[4]

Table II

Auto-transformer control
1 Ma., 141 Kv. (Max.)

Mm. Copper	Time (T) Seconds	Intensity $\frac{1}{T} \times 10$
0.0	4.9	204.0
0.1	17.8	56.2
0.2	27.4	36.5
0.3	36.2	27.62
0.5	54.2	18.50
0.7	72.6	13.79
1.0	102.8	9.73

Table III

Resistance control
1 Ma., 141 Kv. (Max.)

Mm. Copper	Time (T) Seconds	Intensity $\frac{1}{T} \times 10$
0.0	4.7	213.0
0.1	17.3	57.8
0.2	25.4	39.3
0.3	34.3	29.1
0.5	51.0	19.6
0.7	69.1	14.5
1.0	98.6	10.15

Table IV shows the result of dividing the resistance-control by the corresponding auto-transformer control intensities.

Table IV

Mm. Copper	Intensity—Res. Cont. / Intensity—A. T. Cont.
0.0	1.04
0.1	1.03
0.2	1.08
0.3	1.05
0.5	1.06
0.7	1.05
1.0	1.04
Average	1.05

The intensity with resistance control is seen throughout the experiment to be higher than with auto-transformer control,

[4] It is this fraction of the voltage wasted in the rheostat which determines the amount of ballasting action in the case of resistance control.

the difference amounting, on an average, to 5 per cent. This difference may be due to the greater tendency of the tube-load to distort the wave-form, in the direction of flattening the peak, in the case of resistance control. It is very small however, and amounts to but little more than the possible experimental error introduced through the measurement of the high tension voltage.

2. *Interrupterless Machine—Effect of Widely Different Amounts of Ballast Resistance*

The absorption curves of Figure 7 were obtained from ionization chamber meas-

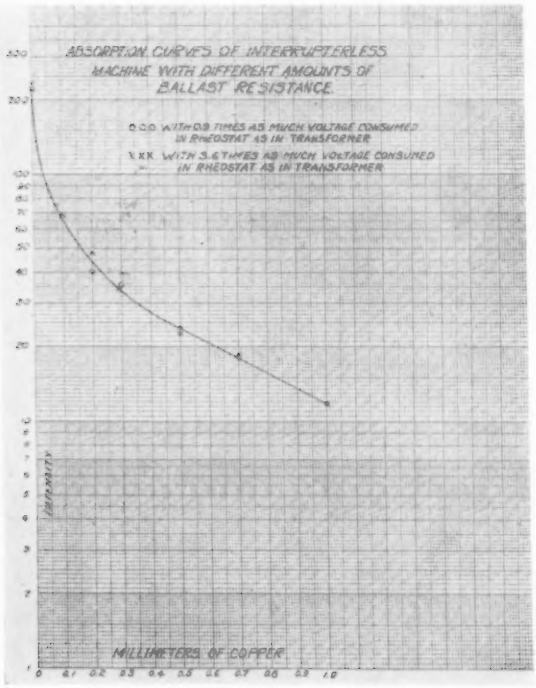

ABSORPTION CURVES OF INTERRUPTERLESS MACHINE WITH DIFFERENT AMOUNTS OF BALLAST RESISTANCE
0.0.0. WITH 0.9 TIMES AS MUCH VOLTAGE CONSUMED IN RHEOSTAT AS IN TRANSFORMER
X.X.X. WITH 3.6 TIMES AS MUCH VOLTAGE CONSUMED IN RHEOSTAT AS IN TRANSFORMER
INTENSITY
MILLIMETERS OF COPPER

FIG. 7

urements, while the tube was operated from an earlier model, Waite & Bartlett interrupterless machine.

A special rheostat was used in the primary circuit and different primary connections were employed for the two curves. The data are given in Tables v and vi.

Inspection of Figure 7 shows that the graph best fitting the data of Table v coincides with that for the data of Table vi.

TABLE V

PRIMARY CONNECTIONS 1 AND 3, WITH 0.9 AS MUCH VOLTAGE CONSUMED IN THE CONTROL RHEOSTAT AS IN THE TRANSFORMER PRIMARY
1 Ma., 141 Kv. (Max.)

Mm. Copper	Time (T) Seconds	Intensity $\frac{1}{T} \times 10^3$
0.0	4.5	222.0
0.1	15.0	66.5
0.2	24.8	40.3
0.3	28.2	35.4
0.5	42.4	23.6
0.7	56.9	17.6
1.0	85.2	11.7

Note. The intensity values of Tables v and vi are not directly comparable with those of Tables i and ii, as the constant of the electroscope may have changed. The slope of the absorption curves can, however, be compared. It is the same throughout, indicating the same quality of radiation from the two different machines.

TABLE VI

PRIMARY CONNECTIONS 3 AND 4, WITH 3.6 TIMES AS MUCH VOLTAGE CONSUMED IN CONTROL RHEOSTAT AS IN TRANSFORMER PRIMARY
1 Ma., 141 Kv. (Max.)

Mm. Copper	Time (T) Seconds	Intensity $\frac{1}{T} \times 10^3$
0.0	4.3	233.0
0.1	14.7	68.0
0.2	20.9	47.8
0.3	29.4	34.0
0.5	44.8	22.3
0.7	55.4	18.1
1.0	84.6	11.8

This extremely wide range of ballasting effect shows then, no change in either the intensity or the kind of *x*-rays produced.

3. *Interrupterless Machine vs. Induction Coil*

For the first of these measurements a large Scheidel-Western induction coil, was employed. It was operated from a mercury turbine interrupter with hydrogen used as the dielectric.

For comparison with this coil, the Snook direct-current interrupterless machine, previously mentioned, was used with resistance control.

The maximum voltage was measured in both cases by a sphere-gap. In the case of the interrupterless machine the voltage was controlled by means of a voltmeter

connected across the primary, and with the coil it was controlled by means of an Abraham-Villard high tension electrostatic voltmeter connected in parallel with the tube.

terless machine was the large experimental one described in Section C.

The comparison was made at 1 ma. and 296,000 volts.

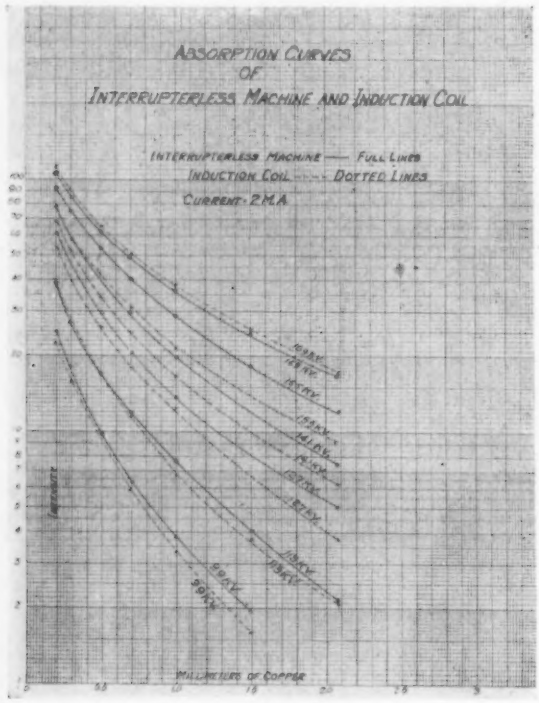


FIG. 8

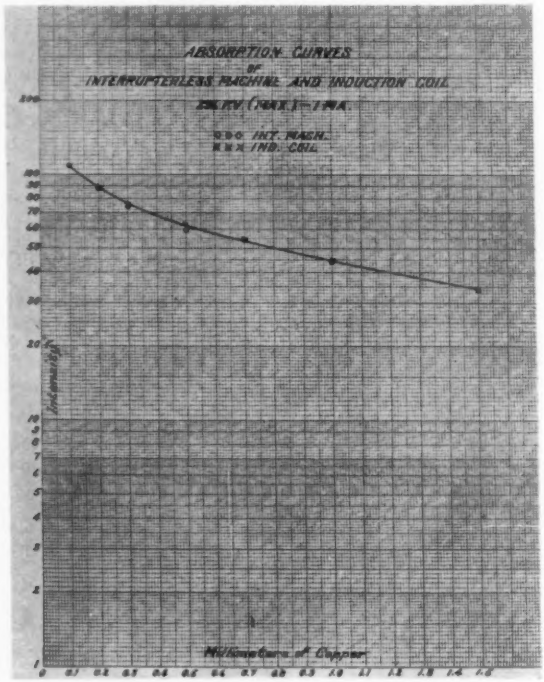


FIG. 9

The ionization currents for the different voltages, expressed in kilovolts (max.) and for different thicknesses of copper filter are given in Tables VII and VIII, and are plotted in Figure 8.

TABLE VII

IONIZATION CURRENTS

SNOOK D. C. INTERRUPTERLESS MACHINE—2 MA.

Millimeters of Copper	99 Kv.	113 Kv.	127 Kv.	141 Kv.	155 Kv.	169 Kv.
0.2	24.8	38.7	60.2	78.0	92.5	105.2
0.3	17.7	26.7	45.0	57.5	74.6	84.7
0.5	9.78	17.15	29.2	39.7	53.2	62.8
0.7	6.35	11.65	20.7	28.7	40.0	49.0
1.0	3.79	7.60	13.63	19.5	29.1	36.7
1.5	1.94	4.08	8.00	11.67	18.13	24.5
2.08	.....	2.14	4.97	7.80	12.35	16.7

A second comparison between induction coil and interrupterless machine was made later at higher voltage. In this case a different induction coil was used. The interrup-

The data are given in Tables IX and X and plotted in Figure 9.

Both sets of data are best represented by the same line, showing that, in so far as is indicated by this test, any existing difference in quality or intensity is less than the experimental error of the measurements.

4. *Interrupterless Machine vs. Constant-Potential Continuous-Current Machine*

The interrupterless machine was the large experimental model described in Section C.

The high tension voltage was measured by the sphere-gap. In both cases, resistance control was employed and the high tension voltage was kept constant by hand regula-

tion of the low tension voltage, indicated by a voltmeter connected across the primary. That the high tension voltage remained constant was also indicated in the case of the high tension direct-current machine by an Abraham-Villard electrostatic voltmeter which was connected in parallel with the tube.

TABLE VIII

IONIZATION CURRENTS
SCHEIDEL-WESTERN INDUCTION COIL—2 MA.

Millimeters of Copper	99 Kv.	113 Kv.	127 Kv.	141 Kv.	155 Kv.	169 Kv.
0.2	22.4	39.7	54.0	68.0	76.8	113.7
0.3	15.77	27.0	48.6	52.0	56.9	93.4
0.5	8.45	17.64	25.5	34.0	42.0	66.5
0.7	5.96	11.35	17.9	25.0	31.2	51.4
1.0	3.38	6.65	12.5	16.7	20.8	38.8
1.5	1.60	3.79	6.58	12.0	14.2	25.9
2.08	.....	2.07	3.73	6.25	9.60	17.13

TABLE IX

INDUCTION COIL OUTFIT
1 Ma., 296 Kv. (Max.)

Millimeters of Copper	Time (T) Seconds	Intensity $\frac{1}{T} \times 10^3$
0.1	9.1	109.9
0.2	10.8	90.0
0.3	12.9	77.5
0.5	15.7	63.8
0.7	18.2	55.0
1.0	22.2	45.1
1.5	29.6	33.8

TABLE X

EXPERIMENTAL INTERRUPTERLESS MACHINE
1 Ma., 296 Kv. (Max.)

Millimeters of Copper	Time (T) Seconds	Intensity $\frac{1}{T} \times 10^3$
0.1	9.1	110.0
0.2	11.3	88.6
0.3	13.2	75.8
0.5	16.9	59.2
0.7	18.1	55.3
1.0	22.6	44.3
1.5	29.3	34.1

The ionization currents for the two machines, at the voltages indicated, with the different thicknesses of copper filter, are given in Tables XI and XII.

Three series of measurements were made on the constant-potential continuous-current machine, operating at 200 kv. and 2 ma. The ionization currents are given in Table XI. The last column gives the average values of the three series.

Table XII gives the ionization currents obtained at different voltages with the interrupterless machine, which was also operated at 2 ma.

The results of Tables XI and XII are plotted in Figure 10, in which the dotted line shows the

TABLE XI

CONSTANT-POTENTIAL CONTINUOUS-CURRENT MACHINE
200,000 Volts., 2 Ma., Tube 143

Millimeters of Copper	Ionization Current			
	Series 1	Series 2	Series 3	Mean
0.0	154.0	149.5	156.1	153.2
0.1	70.2	71.5	73.7	71.8
0.3	42.6	42.5	45.9	43.7
0.5	33.4	35.1	34.9	34.8
0.7	26.3	27.7	28.2	27.4
1.0	21.6	22.6	22.0	22.1
2.0	12.5	13.3	13.2	13.0
4.0	5.61	6.39	6.30	6.10
6.0	2.87	3.45	3.40	3.24
8.0	2.02	2.11	1.61	1.91
10.0	1.34	1.33	1.05	1.24

TABLE XII

INTERRUPTERLESS MACHINE
2 Ma., Tube 143

Millimeters of Copper	Ionization Current			
	200 Kv.	212 Kv.	225 Kv.	237.5 Kv.
0.0	125.8	135.0	148.5	162.0
0.1	49.0	57.5	62.2	70.0
0.3	27.4	33.0	39.4	43.9
0.5	19.4	24.6	29.0	35.0
0.7	15.4	20.0	24.6	28.3
1.0	11.45	15.1	19.4	23.2
2.0	5.78	8.48	11.1	13.8
4.0	2.32	3.81	5.14	6.58
6.0	1.052	1.96	2.69	3.69
8.0	0.536	1.075	1.66	2.20
10.0	0.302	0.648	1.03	1.41

values obtained with the constant-potential continuous-current machine. The dotted line is seen to lie between the 225 kv. and 237.5 kv. curves for the interrupterless machine. Inspection also shows that it very closely parallels the 225 kv. curve. This is also brought out in Table XIII in which the fourth column gives the 200 kv., d.c. values divided by the corresponding 225 kv., a.c. values.

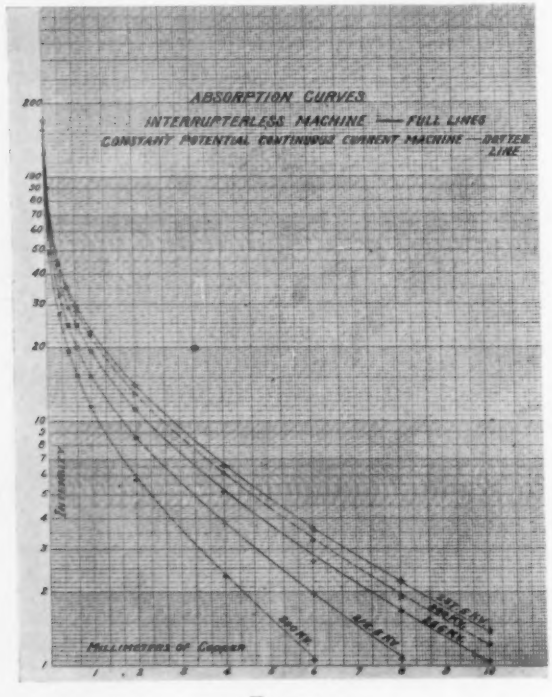

ABSORPTION CURVES
INTERRUPTERLESS MACHINE —FULL LINES
CONSTANT POTENTIAL CONTINUOUS CURRENT MACHINE —DOTTED LINE
Millimeters of Copper

FIG. 10

TABLE XIII

COMPARISON OF IONIZATION CURRENTS WITH D.C. AND A.C. EXCITATION

Millimeters of Copper	(A) 200 Kv., D.C.	(B) 225 Kv., A.C.	A / B
0.0	153.2	148.5	1.031
0.1	71.8	62.2	1.155
0.3	43.7	39.4	1.109
0.5	34.8	29.0	1.200
0.7	27.4	24.6	1.114
1.0	22.1	19.4	1.172
2.0	13.0	11.1	1.187
4.0	6.10	5.14	1.204
6.0	3.24	2.69	1.150
8.0	1.91	1.66	1.205
10.0	1.24	1.03	1.205
Average.....	.....	.....	1.15

The last column of the above table shows no systematic variation with respect to the average value. The 200 kv., d.c. absorption curve can then be duplicated throughout its entire length by 225 kv., a.c. using 15 per cent more milliamperage (2.30 ma.) in the latter case.

Comparison of Percentage Depth-Intensity Values (Under 10 cm. of Water) Obtained with the Constant-Potential Continuous-Current and the Interrupterless Machines

It seemed possible that the voltage of alternating-current excitation equivalent to the 200 kv., d.c., might be somewhat different for equal percentage depth intensity in water than it was as determined by the absorption curves in copper.

To test this out the apparatus was arranged as in Figure 11. The water container consisted of a rectangular brass box 3 cm. wide, 5.5 cm. deep and 10 cm. long lined with aluminum. Thin mica windows were inserted in the two ends. The water-chamber was inserted through a side door in the lead tube and was always placed in the same position, against the end of the filter holder.

The data obtained with the interrupterless machine, operating at 2 ma. and different voltages, are given in Table XIV and plotted in Figure 12. Two different copper filters 0.5 mm. and 1.0 mm. thick were used.

The precision is not all that could be desired. The curves indicate clearly, however, that, up to 250,000 volts at least, the percentage depth-intensity continues to increase with voltage.

The penetration data for the constant-potential continuous-current machine, operating at 200 kv. are given in Table XV. If the percentage depth-intensity values are placed on the curves of Figure 12 it is seen that, with the 0.5 mm. copper filter, the equivalent alternating-current-voltage is 233.2 kv. and that with the 1.0 mm. filter it is 236.5 kv. The average of these is 235 kv.

From the absorption curves in copper the equivalent alternating-current voltage appears to be 225 kv. The difference in these results may be due to experimental error, or it may be due to the fact that the

TABLE XIV

PERCENTAGE DEPTH-INTENSITY UNDER 10 CM. OF WATER—INTERRUPTERLESS MACHINE—2 MA.

Kv.	0.5 Mm. Copper Filter			1.0 Mm. Copper Filter		
	Time (Seconds)		Per Cent Depth-Intensity	Time (Seconds)		Per Cent Depth-Intensity
	Without Water	Under 10 Cm. Water		Without Water	Under 10 Cm., Water	
200.0	17.3	117.4	14.70	29.2	183.7	15.74
	17.3	.....	.....	28.4	.....	.....
	17.2	.....	.....	29.0	.....	.....
	Mean..... 17.27	.....	.....	28.87	.....	.....
212.5	13.7	89.6	15.25	21.4	138.0	15.74
	13.7	.....	.....	21.8	.....	.....
	13.6	.....	.....	22.0	.....	.....
	Mean..... 13.67	.....	.....	21.73	.....	.....
225.0	11.8	73.3	15.73	18.0	107.3	16.71
	11.4	.....	.....	17.8	.....	.....
	11.4	.....	.....	18.0	.....	.....
	Mean..... 11.53	.....	.....	17.93	.....	.....
237.5	9.5	61.2	15.80	15.0	86.4	17.28
	9.8	.....	.....	15.0	.....	.....
	9.7	.....	.....	14.8	.....	.....
	Mean..... 9.67	.....	.....	14.93	.....	.....
250.0	8.7	49.6	17.32	12.7	69.8	18.20
	8.4	.....	.....	12.6	.....	.....
	8.7	.....	.....	12.8	.....	.....
	Mean..... 8.60	.....	.....	12.70	.....	.....

TABLE XV

PERCENTAGE DEPTH-INTENSITY UNDER 10 CM. OF WATER—CONSTANT-POTENTIAL CONTINUOUS-CURRENT MACHINE—200 KV.—2 MA.

With 0.5 Mm. Copper Filter			With 1.0 Mm. Copper Filter		
Time (Sec.) Without Water	Time (Sec.) Under 10 Cm. Water	Percentage Depth-Intensity	Time (Sec.) Without Water	Time (Sec.) Under 10 Cm. Water	Percentage Depth-Intensity
10.0	64.2	.....	15.6	91.0	.....
10.2	.....	.....	15.8	.....	.....
10.6	.....	.....	15.6	.....	.....
10.2	66.6	.....	15.8	92.8	.....
10.8	.....	.....	15.6	.....	.....
10.7	.....	.....	16.1	.....	.....
10.6	65.2	.....	16.0	91.5	.....
10.6	.....	.....	15.6	.....	.....
10.6	.....	.....	15.6	.....	.....
10.6	64.3	.....	15.7	90.5	.....
10.6	.....	.....	15.4	.....	.....
10.6	.....	.....	16.0	.....	.....
Mean 10.51	65.08	16.17	15.73	91.45	17.22

composition of the beam of *x*-rays is not exactly the same in the two cases and that the ratios of scattering to absorption in the two media, copper and water, are different.

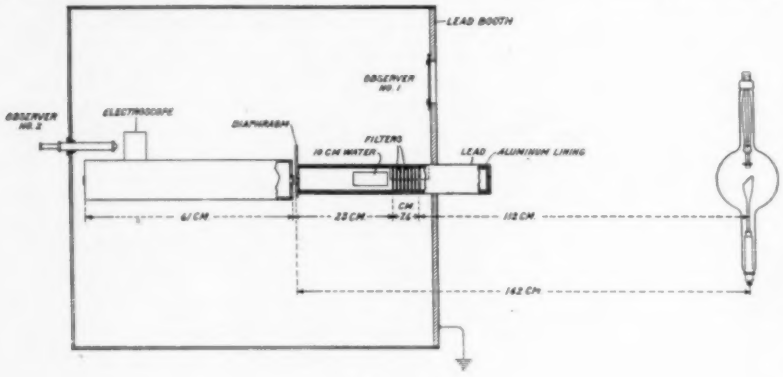


FIG. 11

G. Effect of Electrical Characteristics of High Tension Supply Circuit on Behavior of *X*-Ray Tube

1. *Interrupterless Machine, with Resistance vs. Auto-Transformer Control*

With high voltage operation on the interrupterless machine, resistance control is much easier on the tube than auto-transformer control. It is for this reason that resistance control has always been used for operating hot-cathode tubes on the pump during their evacuation. The resistance in the primary circuit serves as a dam to check the large flow of energy which would otherwise take place to the tube in case, for any reason, its conductivity is suddenly greatly increased. No such dam is present in the case of the auto-transformer control.

A tube whose vacuum has been seriously impaired by operation on a current source having unfavorable characteristics will often clear right up and run smoothly on an interrupterless machine with resistance control.

In addition to its ordinary ballasting action, resistance in the primary circuit also helps to dam out high frequency oscillations originating in the mechanical rectifier, or, in the case of too poor a vacuum, in the tube itself, or from other causes such as the sudden opening or closing of the primary circuit.

2. *High Voltage Transformer with No Auxiliary Rectifying Device*

Twelve new "Universal" type tubes were taken just as they came from the factory and were operated at 140,000 volts (max.) on an interrupterless machine with resistance control. They all ran smoothly. The rectifying switch was then stopped and the tubes were operated directly from the transformer on alternating current, care being taken to use a very low milliamperage so that the focal spot should not become too hot and that the "inverse" should not become appreciably higher than the "useful" voltage.

Under these conditions ten of these tubes ran nicely on alternating current. The other two suffered a rapid impairment of vacuum, as indicated by a vivid green

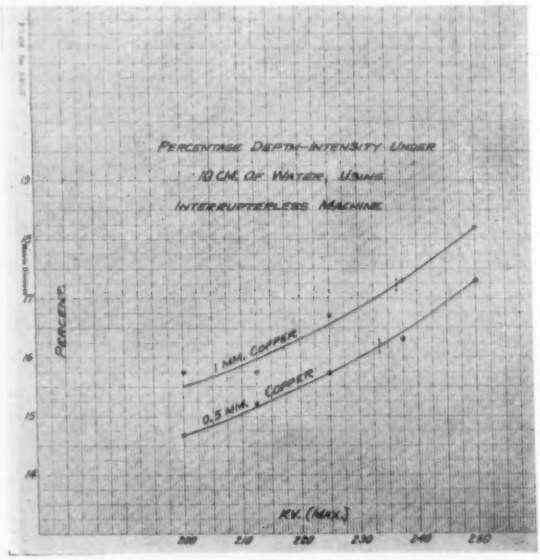


FIG. 12

fluorescence throughout the bulb, and with continued operation would certainly have punctured. Upon again operating these two tubes on the mechanical rectifier, the vacuum cleared right up and they ran as smoothly as before. This cycle of operations

was repeated with both of these tubes with exactly the same result as before.

This and numerous other experiments which have been tried indicate that some "Universal" type tubes will operate at a higher voltage on rectified current than they will when they are forced to rectify their own current.

The operation of tubes directly from a transformer without auxiliary rectifying device is further complicated by the fact that for satisfactory operation, this method calls for auto-transformer rather than resistance control as otherwise the "inverse" voltage becomes appreciably higher than the "useful." We have already seen that the use of auto-transformer control is harder on tubes.

Later experiments have shown that "high voltage" tubes which may operate in an experimental way at as much as 300,000 volts with rectified current will, as a rule, not run smoothly at more than 200,000 volts when rectifying their own current. The tube rectifying its own current at 200,000 volts will, furthermore, not inspire the same feeling of confidence as when operating from rectified current at 300,000 volts.

3. *Induction Coil*

A given "high voltage" tube may stand as high voltage on the induction coil[5] as it does on the interrupterless machine, but, the chances are against it, as shown by the statistics of Table XVI.

Of the tubes which operate satisfactorily on the interrupterless machine at the voltage shown in the first column of Table XVI, the percentage which operate as high as this on the coil is given by the second column.

TABLE XVI

Voltage	Percentage
200,000	54
250,000	21
300,000	11

These results have been obtained with "high voltage" tubes as they come from the factory.

[5] Operated with a mercury-turbine interrupter with gas dielectric.

The behavior of a few of the individual tubes is indicated in Table XVII.

Experience has shown that the numbers in the table are really characteristic of the tubes and that the differences indicated are very consistent. It is quite striking to find some tubes operating smoothly at 300,000 volts on the interrupterless machine and carrying less than 140,000 volts on the coil.

The underlying causes call for further study.

TABLE XVII

MAXIMUM VOLTAGE FOR QUIET OPERATION

Tube	Interrupterless Machine	Induction Coil
A	300,000	225,000
B	300,000	140,000
C	300,000	140,000
D	300,000	140,000
E	300,000	250,000
F	295,000	140,000
G	300,000	210,000
H	300,000	250,000

4. *Constant-Potential Continuous-Current Machine*

Tubes operate very smoothly on the constant-potential continuous-current machine, described in Section D.

Fifteen tubes were tested on this machine with a current of 5 ma. and then on the interrupterless machine at currents of 2 and 5 ma. The maximum voltages at which the different tubes ran quietly are given in Table XVIII. A + sign after the

TABLE XVIII

MAXIMUM VOLTAGE FOR QUIET OPERATION

Tube No.	Constant-potential Continuous-current Machine	Interrupterless Machine	
	5 Ma.	2 Ma.	5 Ma.
268	200,000+	245,000+	.....
247	200,000+	245,000+	.....
140	200,000+	255,000	250,000
129	200,000+	280,000	250,000+
143	200,000+	255,000	225,000
130	200,000+	235,000	235,000
116	200,000+	255,000	225,000
137	200,000+	255,000+	210,000
125	200,000+	295,000	250,000
153	180,000	210,000	205,000
152	180,000	210,000	210,000
136	180,000−	255,000	180,000
157	150,000	220,000+	250,000
146	130,000−	210,000	180,000
141	115,000−	230,000	110,000

number indicates that the tube could have supported more voltage, and a − sign indicates that its behavior was not quite satisfactory at the given voltage.

Bearing in mind that, according to Part 4 of Section F, the constant-potential machine at 200,000 volts gives the same penetration through 10 cm. of water as the interrupterless machine at 235,000 volts, it may be said that, for the same end result, as measured in this way, the present tubes seem to operate as well on the constant-potential machine as on the interrupterless machine.

H. *X*-Ray Output of Different Tubes Operating Under the Same Electrical Condition

1. *Comparison of X-Ray Output of 20 "High Voltage" Tubes, Operating on the Interrupterless Machine at 200,000 Volts (Max.) and 2 Milliamperes*

Twenty high voltage tubes were taken just as they came from the factory and were in turn operated at a definite distance in front of an ionization chamber.

Care was taken to choose such a distance and such a diaphragm opening that radiations from the entire focal spot should reach the ionization chamber, even in the case of the largest focal spot and, in addition to this, that there should be sufficient margin to make the proper location of the tube an easy matter. The distance and diaphragm opening were also so chosen that no direct radiation should impinge upon either of the electrodes of the ionization chamber.

The ionization currents were measured with a gold-leaf electroscope and stop-watch, the timed excursion of the leaf always being the same.

The results are given in Table XIX. The times in the second column are obtained with no filter, those in the third column, A, with a filter consisting of 0.2 mm. of copper and those in the fourth column, B, with a copper filter 1 mm. thick. The last column gives the calculated ratio of A to B, which may be taken as a relative measure of the penetrating power of the radiations.

The averages of the various columns are found below and, on the last horizontal line, the average percentage deviation of the single observations from the mean.

Table XIX

200,000 volts (max.)—2 ma.

Tube No.	Time (Sec.) No Filter	A Time (Sec.) 0.2 mm. Copper	B Time (Sec.) 1.0 mm. Copper	A / B
132	8.8	42.4	113.1	0.375
161	14.8	44.0	113.7	0.387
146	10.3	43.1	114.8	0.375
130	10.1	42.8	115.0	0.372
129	10.7	42.4	113.8	0.373
125	10.7	43.3	112.8	0.384
140	12.3	42.0	113.1	0.371
137	9.0	42.4	111.4	0.381
136	11.0	43.4	112.7	0.385
147	7.9	42.3	111.9	0.378
131	10.8	43.9	112.3	0.392
152	11.0	42.4	111.7	0.380
123	10.8	42.0	110.3	0.381
153	9.7	43.4	114.7	0.378
148	9.7	42.3	111.6	0.378
111	10.0	43.3	115.6	0.375
118	9.0	42.6	110.7	0.384
116	9.7	42.3	111.3	0.380
155	13.6	42.8	108.2	0.392
157	10.7	42.4	109.9	0.386
Average	10.53	42.77	112.43	0.3803
a. d. %	9.6	1.25	1.33	1.29

Inspection of the results shows that if no filter is used different tubes vary appreciably in their *x*-ray output. This is to be accounted for by differences in the wall thickness of the different bulbs.

Where a filter equivalent to as much as 0.2 mm. of copper is used, the effect of variations in bulb thickness becomes negligible; the observed differences in the output of the various tubes is but little more than the experimental error of the observations. Under such a filter then, the quantity and penetrating power of the radiations coming from the twenty tubes showed an average variation from the mean of only a little more than 1 per cent.

It is also interesting to compare the extremes in the series. This is done in Table XX. Used without a filter, tubes 147 and 161 show a difference in ionization current of 87.5 per cent. With the filters, the extreme differences are relatively small.

TABLE XX
EXTREMES IN THE SET OF 20 TUBES

Tube No.	Time in Seconds		
	No Filter	0.2 mm. Copper	1.0 mm. Copper
147	7.9	.....	.....
161	14.8	.....	.....
161	....	41.81	.....
140	....	39.50	.....
111	....	.....	107.6
155	....	.....	104.4
Difference in %	87.5	5.5	3.1

2. *Comparsion of X-Ray Output of 7 "Broad" Focus "Universal" Type Tubes, Operating on Interrupterless Machine at 127,000 Volts (Max.) and 5 ma.*

The effect of varying bulb thickness should be greater at lower voltages and it seemed interesting to compare some "Universal" type tubes under the conditions in which they are used in therapy. As both "medium" and "broad" focus tubes have been employed, a set of each was studied.

A voltage of 127,000 volts (max.) was used, corresponding to about a 9 inch spark between the ordinary blunt points. This was obtained from the interrupterless machine described in Section C.

Aluminum filters of 3 and 6 mm. thickness were employed.

TABLE XXI
"BROAD" FOCUS "UNIVERSAL" TYPE TUBES
127,000 VOLTS (MAX.) 5 MA.

Tube No.	Time (Seconds)		
	No Filter	3 mm. Aluminum Filter	6 mm. Aluminum Filter
37402	7.75	33.4	62.4
22727	9.71	35.1	63.5
37396	7.60	33.2	61.6
37400	9.55	36.0	65.7
37452	8.33	34.5	63.2
37392	7.30	32.1	59.7
37393	7.25	32.3	60.8
Average.....	8.21	33.8	62.4
a. d. %.....	10.2	3.55	2.35

The results are given in Tables XXI and XXII.

TABLE XXII
"MEDIUM" FOCUS "UNIVERSAL" TYPE TUBES
127,000 VOLTS (MAX.)—5 MA.

Tube No.	Time (Seconds)		
	No Filter	3 mm. Aluminum Filter	6 mm. Aluminum Filter
37391	7.05	33.1	61.3
37389	6.93	32.6	60.4
37390	8.08	34.2	59.2
22376	5.83	31.9	60.3
37387	7.50	32.8	62.0
37376	7.00	33.5	62.9
37394	8.25	34.9	64.7
36976	7.30	32.6	60.6
36977	7.65	35.1	65.1
36994	7.45	33.6	62.2
Average.....	7.40	33.4	61.9
a. d. %.....	6.5	2.48	2.44

As was to be expected, the "Universal" type tubes, operated at this lower voltage, show greater differences among themselves than did the "High Voltage" tubes operated at 200,000 volts.

As before, the differences between tubes are much less when the intensity measurements are made under a filter.

The results indicate that, as a class, there is no difference in output between the "broad" and the "medium" focus tubes. For this reason they are all classed together for a study of the extremes. See Table XXIII.

TABLE XXIII
EXTREMES IN 17 TUBES

Tube No.	Time (Seconds)		
	No Filter	3 mm. Aluminum	6 mm. Aluminum
22727	9.71	....	....
22376	5.83	....	....
37400	.....	36.0	....
22376	.....	31.9	....
37400	.....	....	65.7
37390	.....	....	59.2
Difference in %	66.5	12.9	11.0

I. Loss of *X*-Ray Intensity From a Heavy Tungsten Deposit on Bulb

When the focal spot of an *x*-ray tube is overloaded, metal vaporizes from it and condenses on the anterior hemisphere of the bulb. The question has often been raised as to whether such a tungsten deposit formed in this way can ever attain sufficient thickness to appreciably reduce the efficiency of the tube.

To investigate this matter the following experiment was tried: From the tubes which had been returned to the tube factory for repairs, the one was selected which showed the thickest tungsten deposit on the bulb. A piece of glass having an area of 9.6 square centimeters was then cut from the region showing the maximum thickness of deposit.

This piece of glass, with its tungsten deposit was then placed before the ionization chamber and, with an *x*-ray tube operating at 127,000 volts, and 5 ma., the time of discharge of the electroscope was determined with and without filters.

The piece of glass with its deposit was then weighed. After this the tungsten deposit was removed chemically and the piece was again weighed. The difference between the two weighings of course gives the weight of the tungsten layer and from the measured area of the surface in question and the known density of tungsten the thickness of the deposit was calculated.

The glass piece freed from its tungsten deposit was then again placed before the ionization chamber and the previous measurements repeated.

It was found that the glass alone reduced the *x*-ray intensity by the same amount as a filter of 1 mm. of aluminum.

The results are given in Table XXIV.

Table XXIV

Millimeters Aluminum Filter	Time (Sec.) Glass + Tungsten	Time (Sec.) After Removal of Tungsten Deposit	*X*-ray Intensity $\frac{1000}{T}$		Reduction %
			With Tungsten	Without Tungsten	
0	14.35	12.95	69.7	77.2	9.7
2	30.45	28.82	32.9	34.7	5.2
5	58.8	55.7	17.01	17.95	5.2

The last column of the table shows that when no external filter was used the tungsten deposit reduced the *x*-ray intensity, as measured by ionization current, by 9.7 per cent. It should be borne in mind, however, that the glass was itself equivalent to a 1 mm. aluminum filter. If the support glass could have been removed the percentage reduction in intensity due to the tungsten deposit alone would have been considerably greater.

The 2 mm. aluminum filter taken together with the piece of bulb glass was equivalent to 3 mm. of aluminum, and with this the tungsten deposit caused a reduction in intensity of 5.2 per cent. The 5 mm. of aluminum, together with the glass was equivalent to 6 mm. of aluminum and, with this filtration also the reduction of intensity due to the tungsten deposit was 5.2 per cent.

The data relating to the thickness of the tungsten deposit were as follows:

Area of deposit (sq. cm.)	9.6
Weight of glass plus deposit (grams)	2.4817
Weight of glass	2.4620
Weight of tungsten, by difference	0.0197
Specific gravity of W	19.3
Thickness, calculated (in mm.)	0.00106

The experiment just described could have been tried in more simple and direct fashion by comparing the output of the blackened tube with that of a new tube, had it not been for two obstacles. In the first place the tube with its heavy metal deposit would not operate satisfactorily at a voltage as high as 127,000. In the second place, the target was deeply pitted and this, as will be shown in Section J, of itself exerts a much more marked effect on efficiency than does the metal deposit on the bulb.

The measured loss in efficiency due to the heavy deposit was relatively small, only 5.2 per cent under 3 mm. of aluminum, and it seems safe to predict that a "Universal" type of tube, operating at a voltage as high as 127,000 will never show even as much loss in efficiency as this, due to tungsten deposit, for it will doubtless puncture before any such thickness of deposit has been attained.

There is, furthermore, no reason why a broad focus tube used for therapeutic purposes should have any appreciable tungsten deposit on the bulb. Such a deposit would come only from abuse in diagnostic work and would never happen if the tube were used solely for therapy.

J. Loss of Efficiency from the Bad Pitting of a Target

X-rays are produced by the impact upon the target of cathode rays, the path of which, in the "Universal" and "Radiator" types of tube, lies essentially in the axis of the tube. Most work is done with the central beam of *x*-rays which is, in these tubes, essentially perpendicular to the cathode ray stream.

If the focal spot were to lie at the bottom of a deep cylindrical pit whose axis was parallel to the tube axis it is obvious that the passage of the cathode rays to the bottom of the pit would be unimpeded but that the *x*-rays emerging at right angles to this direction would have to pass through a considerable thickness of the target material.

In the case just considered, the resultant efficiency of *x*-ray production in the central beam, expressed in terms of that of a normal tube, might be extremely low.

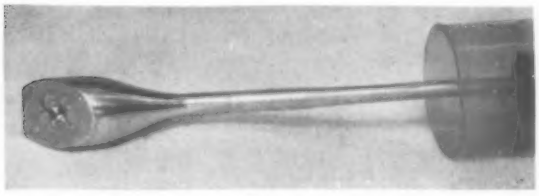


Fig. 13

Although no two pitted targets will be alike, it seemed worth while to study the worst case of pitting which could be found. A selection was made from a lot of used tubes which had been returned to the factory. The tube in question had evidently been heavily overloaded in radiographic work. The condition of the focal spot may be seen from Figure 13. The main cavity was 2.5 mm. deep. The tungsten which had left the focal spot had been deposited on the bulb where it would, of course, exert a certain amount of filtering action. For this reason the target was removed from the old tube and put into a fresh bulb. It was, of course, necessary that the cathode should be so placed as to make the new focal spot register with the old one. By the method of trial and error this was finally accomplished.

The *x*-ray distribution in different directions from this tube is given in Parts 3 and 4 of Section K; its efficiency in two directions, in terms of a tube of like design having a smooth unpitted focal spot, is contained in Table xxv. The two tubes were operated at 127,000 volts (max.) and 3 ma., on the interrupterless machine.

Table xxv

Efficiency of tube with badly pitted target in terms of that of normal tube, both operating at 127,000 volts (max.) and 3 ma.

Filter, Millimeters of Aluminum	Efficiency in Per Cent	
	Central Beam	40° away from Central Beam, Towards Cathode
0	42	69
3	70	95
6	78	103

Too much attention should not be given to the value of efficiency where no filter was used, as no attempt was made to use bulbs of the same wall thickness.

It is pleasant to find that, even in this extremely bad case of pitting, the efficiency in the central beam is, with the 3 mm. filters, as high as 70 per cent. Where a tube having a large focal spot is used for therapy only, there will be no pitting of the focal spot and the effect of slight roughening and of thin cracks whose area is small compared with the total area of the focal spot, will obviously be very small.

The effect of pitting in lowering efficiency could be reduced by using rays coming from a direction other than that of the central beam, as, for example, in the other direction referred to in the table. This practice seems undesirable, however, as it tends to bring the cathode end of the tube too close to the patient.

K. Distribution of *X*-Ray Intensity in Different Directions from a 45-Degree Tungsten Target

If dosage is to be determined in therapy from the measurement of the current and voltage supplied to the tube, taken in

conjunction with the factors of time, distance, filter thickness and port of entry, it becomes necessary to know something about the distribution of the *x*-ray intensity radiating in different directions from the focal spot.

It has been customary to work with the central beam of rays and there are good reasons for this practice, but, it is, of course, desirable to know, from actual experiment, how much difference in intensity will be caused by a given inaccuracy in the setting of the tube.

For the following measurements the apparatus was arranged as in Figure 11, with the exception that the water-cell shown there was, of course, not used. The tube was placed with the axis horizontal, and was so mounted that it could be rotated about its own axis and about a vertical axis passing through the center of the focal spot. The degree of rotation about each axis was indicated by a graduated circle.

The tube and its holding device were so adjusted, by sighting through the ionization chamber and diaphragm system, and by the help of a cathetometer, that the focal spot was properly located with respect to the ionization chamber and that the two axes of rotation passed through the center of the focal spot.

In all cases a solid tungsten target was used, having the shape and size employed in the "Universal" type of tube.

The diaphragm next to the tube was large enough to admit to the ionization chamber the radiation from the whole working face and nearly the whole head of the target. This means then that not only the rays from the focal spot but also the radiation from the balance of that side of the head of the target was included in the measurements. This was intentional, for this same condition pertains in the ordinary use of the tube.

The intensity was determined by measuring the charging rate of the Bumstead electroscope.

1. *Distribution Around Girdle of Tube, with 200,000 Volts (Max.), 2 Milliamperes and Interrupterless Machine*

Table XXVI gives the distribution of intensity around the girdle of a High Voltage tube (No. 154) operating on the interrupterless machine at 200,000 volts (max.) and 2 ma.

The interpretation of the first column in the table will be clear from the direction diagram in Figure 14. This shows an end view of the target. The focal spot is indicated by the small circular stippled area and the direction of the central ray is taken as zero degrees.

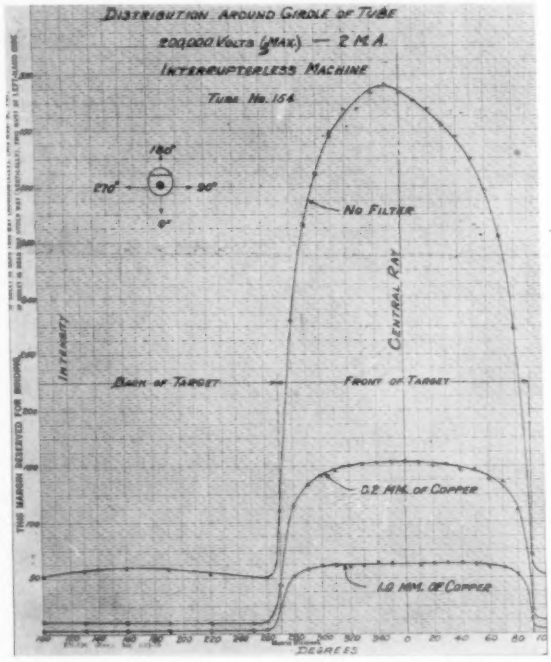


FIG. 14

The second, third and fourth columns give the *x*-ray intensity as measured by the ionization current with no filter, 0.2 mm. and 1.0 mm. of copper. The last column gives the quotients obtained by dividing the intensities under 1 mm. of copper by the corresponding values for 0.2 mm. of copper. The values of the last column may then be taken as a rough qualitative measure of the penetrating power of the radiations in the different directions. It is seen that the penetrating power of the radiations coming from the back of the target is less than that of those coming from the front. It is also seen that for the radiations coming from the front, the penetrating power increases as glancing incidence is approached on both sides of the central beam. This last

TABLE XXVI

DISTRIBUTION OF INTENSITY AROUND GIRDLE OF TUBE, WITH 200,000 VOLTS (MAX.), 2 MA. AND AN INTERRUPTERLESS MACHINE—TUBE 154

Direction (Degrees)	No Filter	A 0.2 Mm. Copper	B 1.0 Mm. Copper	B / A
90	71.9	23.7	14.08	0.595
80	273.0	111.8	52.7	0.471
70	355.0	135.8	59.3	0.437
60	397.0	137.9	60.2	0.437
50	424.0	147.0	62.5	0.425
40	444.0	147.0	62.8	0.427
30	455.0	151.1	63.6	0.419
20	469.0	150.1	62.6	0.417
10	476.0	154.1	61.6	0.400
0	483.0	154.1	62.6	0.405
350	490.0	154.1	62.8	0.407
340	483.0	152.3	63.9	0.419
330	469.0	152.3	60.8	0.399
320	469.0	150.1	60.2	0.401
310	447.0	146.0	62.2	0.426
300	412.0	142.0	61.5	0.433
290	365.0	135.8	57.3	0.422
280	280.0	115.8	52.4	0.453
270	110.6	43.4	25.6	0.590
260	49.7	10.20	3.08	0.302
250	51.0	9.29	3.12	0.336
220	54.3	10.52	3.11	0.295
190	58.8	11.31	3.15	0.278
160	59.9	11.21	3.33	0.297
130	56.9	11.01	3.07	0.278
100	52.2	11.13	3.55	0.318
90	77.0	18.12	.....	.....

TABLE XXVII

DISTRIBUTION OF INTENSITY IN PLANE CONTAINING TUBE AXIS AND PERPENDICULAR TO TARGET FACE—200,000 VOLTS (MAX.)—2 MA.—INTERRUPTERLESS MACHINE—TUBE 154

Direction (Degrees)	No Filter	A 0.2 Mm. Copper	B 1.0 Mm. Copper	B / A
−50	55.4	13.95	4.07	0.291
−40	166.1	83.9	41.6	0.499
−30	372.0	144.3	65.0	0.450
−20	452.0	155.0	66.7	0.431
−10	495.0	154.0	65.8	0.427
0	486.0	151.3	62.8	0.415
10	451.0	146.0	59.5	0.407
20	412.0	140.4	58.0	0.413
30	379.0	138.0	56.2	0.407
40	368.0	137.2	55.3	0.403
50	376.0	131.5	53.8	0.409
60	400.0	132.1	54.8	0.414
70	373.0	116.4	51.3	0.441
110	300.0	119.8	54.3	0.453
120	269.0	116.4	51.3	0.441
130	218.0	104.0	47.6	0.457
140	39.9	11.17	3.36	0.303
150	.....	10.64	2.81	0.264
160	44.7	10.32		
170	65.7	9.89		

effect is doubtless due to the fact that as glancing incidence is approached, the *x*-rays as they emerge from the target metal have to pass through a greater and greater thickness of tungsten which, of course, exerts a filtering action.

The *x*-ray intensity values are plotted in Figure 14.

It will be seen that, with no filter, the intensity is greatest in a direction close to that of the central ray.

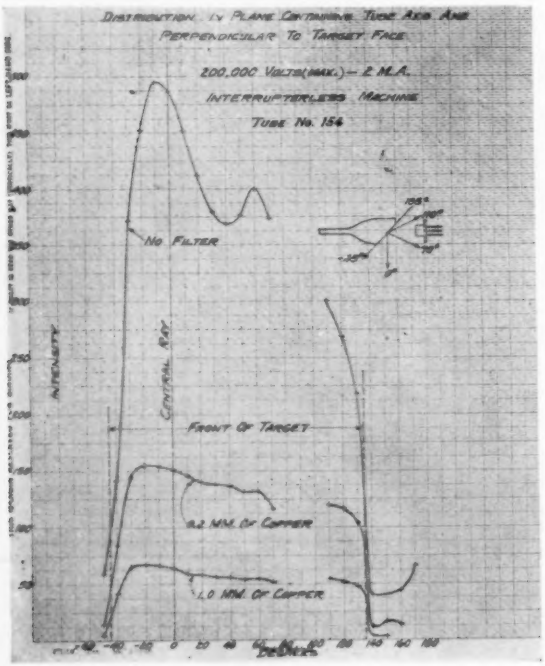


Fig. 15

The distribution curve is appreciably flattened by the use of the filters. On going, for example, from 350° to 320° the intensity falls off with no filter 5.1 per cent, with 0.2 mm. of copper 2.1 per cent and with 1 mm. of copper there is no measurable change.

At the back of the target the intensity reaches a maximum at a point close to 180° where it should be a maximum from geometrical considerations.

The maximum intensity from the back of the target with no filter is 12.2 per cent of the maximum from the front of the target; with 0.2 mm. of copper filter it is 7.4 per cent and with 1 mm. of copper filter it is 5.2 per cent. The average penetrating power of the radiations coming from the back of the target is then seen to be less than that of the radiations coming from the front.

2. *Distribution in Plane Containing Tube Axis and Perpendicular to Target Face, with 200,000 Volts (Max.), 2 ma., and Interrupterless Machine*

The data from this experiment, obtained by first placing the tube so that the central ray was passing into the ionization chamber and then rotating the tube about the

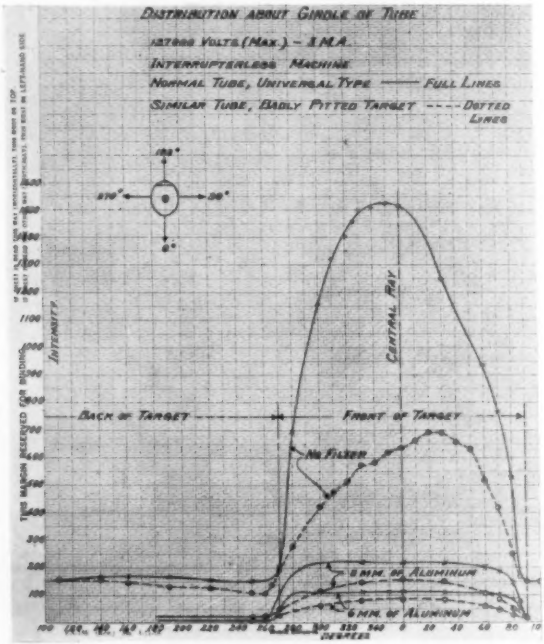


Fig. 16

vertical axis, are given in Table XXVII and plotted in Figure 15.

The significance of the numbers of the first column of the table will be made clear by reference to the direction diagram of Figure 15. The other columns have the same significance as the corresponding columns of the preceding table.

From 70 to 110 degrees there is a gap which cannot be filled in, owing to the presence of the cathode structure.

From the values of $\frac{B}{A}$ it is seen that the rays are least penetrating in a direction normal to the face of the target and that the penetrating power increases on both sides of this direction as glancing incidence is approached.

It will be noted that, with no filter, the intensity maximum in this plane lies about 10 degrees away from the central beam towards the heel of the target and, with 0.2 mm. and 1.0 mm. of copper filter, about 20° from the central beam.

The direction of maximum intensity appears then to make an acute angle with the cathode rays. This might be accounted for by the assumption of a Doppler effect. It seems more probable, however, that it is mainly due to the following circumstances: In the hot cathode type of tube and with a target having a 45° face, the cathode ray stream does not remain parallel to the axis of the tube but is electrostatically deflected towards the toe of the target. It may very well be then that the intensity maximum lies in a direction perpendicular to the cathode-rays at the point of their impact with the target face, as suggested by the simple theory of polarization without the Doppler effect.

As in the equatorial plane, the intensity curves are somewhat flattened by filtration.

3. *Distribution Around Girdle of Tube, with 127,000 Volts (Max.), 3 Milliamperes, and Interrupterless Machine, Using "Universal" Tube No. 22376 and a Similar Tube Having a Badly Pitted Target*

Tube 22376 was an ordinary "Universal" type of tube with a "medium" focus. The other tube was the one referred to in Section J. It was entirely similar in design but had the badly pitted target shown in Figure 13.

TABLE XXVIII

DISTRIBUTION AROUND GIRDLE OF TUBE, WITH 127,000 VOLTS (MAX.), 3 MA. AND INTERRUPTERLESS MACHINE

Direction (Degrees)	Tube 22376				Similar Tube, Badly Pitted Target			
	No Filter	A 3 Mm. Aluminum	B 6 Mm. Aluminum	B A	No Filter	A 3 Mm. Aluminum	B 6 Mm. Aluminum	B A
0	1520.0	216.0	111.3	0.51	636.0	155.5	82.5	0.53
350	1526.0	.....	.....	....	618.0	.....	.....	....
340	1505.0	.....	.....	....	582.0	.....	.....	....
330	1500.0	221.0	111.7	0.51	572.0	142.8	78.7	0.55
320	1401.0	.....	.....	....	515.0	.....	.....	....
310	1320.0	.....	.....	....	477.0	.....	.....	....
300	1153.0	217.0	111.0	0.51	422.0	114.0	61.0	0.53
280	690.0	.....	.....	....	278.0	.....	.....	....
270	209.0	101.3	55.8	0.55	191.7	48.3	25.7	0.53
265	.....	.....	10.46	....	134.8	.....	.....	....
260	160.0	23.1	10.30	0.45	105.7	20.8	10.30	0.50
250	155.0	22.3	.....	....	107.4	19.4	9.45	0.50
220	157.0	.....	.....	....	124.6	.....	.....	....
190	168.5	.....	.....	....	129.7	.....	.....	....
180	.....	23.1	9.95	0.43	.....	.....	.....	....
170	.....	.....	.....	....	.....	22.6	11.31	0.50
160	167.4	.....	.....	....	142.3	.....	.....	....
140	169.0	.....	.....	....	154.0	.....	.....	....
110	152.0	.....	.....	....	154.0	.....	.....	....
100	151.5	.....	.....	....	148.7	.....	.....	....
90	148.3	21.5	10.23	0.48	148.7	21.8	10.86	0.50
85	.....	71.5	52.2	0.73	164.0	.....	.....	....
80	529.0	147.4	84.4	0.57	248.0	48.2	25.2	0.52
70	767.0	186.5	100.5	0.54	417.0	80.9	43.3	0.53
60	936.0	201.0	106.0	0.53	516.0	101.6	55.8	0.55
50	1046.0	.....	.....	....	630.0	.....	.....	....
40	1160.0	.....	.....	....	654.0	.....	.....	....
30	1250.0	219.0	111.0	0.51	690.0	148.2	80.0	0.54
20	1329.0	.....	.....	....	690.0	.....	.....	....
10	1382.0	.....	.....	....	662.0	.....	.....	....

The numerical results are given in Table XXVIII and are plotted in Figure 16.

The general conclusions to be drawn from the data on the normal tube are the same at 127,000 volts as they were at 200,000 volts.

With the normal tube, the maximum intensity from the back of the target with no filter is 11.1 per cent of the maximum from the front of the target; with 3 mm. of aluminum filter it is 10.4 per cent and with 6 mm. of aluminum filter it is 9.0 per cent.

Apart from its effect of reducing intensity, bad pitting is clearly a disadvantage, for as the curves show, in the cases where filters were used, it greatly reduces the angle through which the intensity is essentially constant.

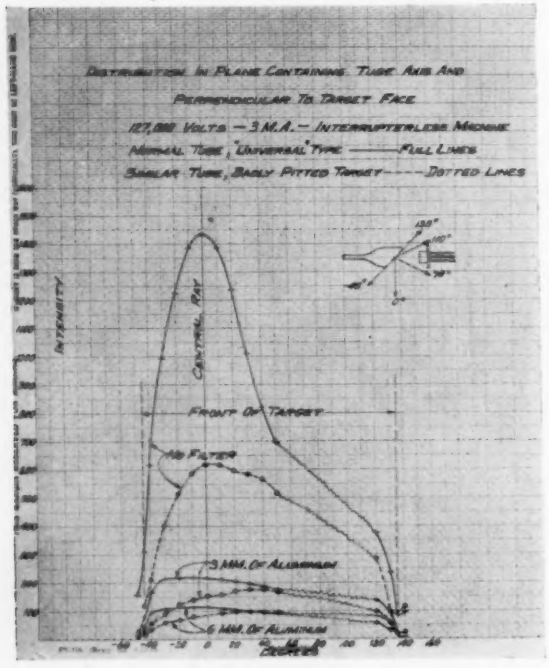

Distribution In Plane Containing Tube Axis And
Perpendicular To Target Face
127,000 Volts — 3 M.A. — Interrupterless Machine
Normal Tube, "Universal" Type ——— Full Lines
Similar Tube, Badly Pitted Target - - - - Dotted Lines
Intensity
Central Ray
Front Of Target
No Filter
3 MM. Of Aluminum
6 MM. Of Aluminum

FIG. 17

The results are given in Table XXIX and plotted in Figure 17.

In the case of the normal tube the intensity curves are markedly flattened by the use of the filters.

The intensity curves for the badly pitted target approach those of the normal tube as the direction approximates that of the cathode ray stream.

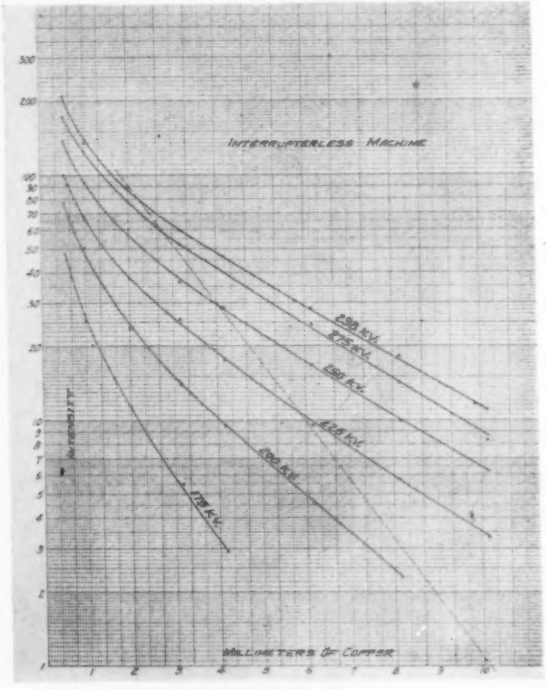


FIG. 18

L. Absorption Curves with Copper Filters for Voltages up to 298 Kv. (Max.)

The absorption data of Table XXX were obtained with high voltage tube V117, operating on the interrupterless machine described in Section B with a current of 2 ma. The apparatus was arranged as in Fig. 4. The ionization current was measured by means of a Bumstead electroscope and stop-watch and the *x*-ray intensity is assumed to be inversely proportional to the time, T, required for the image of the gold leaf to travel from 2 to 10 on the scale of the reading telescope. The time varied from 4 to 400 seconds.

The voltage is expressed in kilovolts (max.).

4. *Distribution in Plane Containing Tube Axis and Perpendicular to Target Face, with 117,000 Volts (Max.) 3 Milliamperes, and Interrupterless Machine, using "Universal" Tube No. 22,376 and a Similar Tube Having a Badly Pitted Target*

TABLE XXIX

DISTRIBUTION IN PLANE CONTAINING TUBE AXIS AND PERPENDICULAR TO TARGET FACE, 127,000 VOLTS (MAX.)—3 MA.—INTERRUPTERLESS MACHINE

Direction (Degrees)	Tube 22376				Similar Tube, Badly Pitted Target			
	No Filter	A 3 Mm. Aluminum	B 6 Mm. Aluminum	$\frac{B}{A}$	No Filter	A 3 Mm. Aluminum	B 6 Mm. Aluminum	$\frac{B}{A}$
0	1433.0	219.0	111.7	0.51	614.0	150.7	.....	....
−10	1388.0	217.0	111.4	0.51	582.0	138.8	75.1	0.54
−20	1223.0	216.0	112.7	0.52	511.0	122.0	64.8	0.53
−30	995.0	212.0	110.5	0.52	400.0	98.5	54.8	0.56
−40	615.0	164.2	95.0	0.58	210.0	52.7	30.0	0.57
−45	310.0	80.1	44.5	0.56	117.0	26.2	14.4	0.55
−50	154.0	27.6	12.90	0.47	.....	.....	10.47	....
10	1385.0	211.0	106.0	0.50	618.0	158.1	89.6	0.57
20	1235.0	204.0	102.0	0.50	596.0	170.4	94.7	0.56
30	1010.0	194.5	98.8	0.51	582.0	174.0	97.5	0.56
40	820.0	183.7	93.8	0.51	568.0	175.2	94.7	0.54
50	694.0	176.0	89.3	0.51	513.0	167.9	93.3	0.56
120	374.0	138.2	79.9	0.58	283.0	93.1	54.0	0.58
130	234.0	90.0	54.1	0.60	92.5	52.0	29.6	0.57
140	87.0	18.75	9.10	0.48	111.1	22.5	10.82	0.48
150	96.0	19.25	9.19	0.48	117.0	.....	.....	....

The data of Table xxx are plotted in Figure 18.

It is interesting to note that the portion of the curves lying to the right of the dotted line is essentially straight and that those straight portions are all essentially parallel to one another.

TABLE XXX

INTERRUPTERLESS MACHINE—TUBE V117—2 MA.

Millimeters of Copper	Intensity $= \frac{I}{T} \times 1000$					
	175 Kv.	200 Kv.	225 Kv.	250 Kv.	275 Kv.	298 Kv.
0.098	125.0	178.5	.....	.....	.....	.....
0.196	88.0	137.0	.....	.....	.....	.....
0.294	73.0	105.2	.....	.....	.....	.....
0.49	48.1	77.7	100.0	139.0	173.0	209.0
0.69	36.0	64.1	.....	.....	.....	.....
0.98	25.2	50.5	66.7	92.8	125.0	135.0
1.48	16.67	33.6	.....	.....	.....	.....
1.97	11.22	23.4	38.0	56.2	78.2	90.0
3.15	5.45	13.80	25.2	36.2	52.7	60.3
4.19	2.91	9.36	17.63	28.7	40.0	46.8
6.27	.....	4.57	9.52	16.6	24.6	28.5
8.35	.....	2.28	5.65	9.88	14.4	18.2
10.43	.....	.....	3.44	6.23	8.28	11.0

In a general way, the quality of the radiation is indicated by the slope of these absorption curves and, in so far as this is true, the curves show that increasing the thickness of the copper filter beyond a certain point does not essentially change the quality of the radiations. They also show that, with sufficient copper filtration the quality, as indicated in this manner, is essentially the same through the range from 225 to 298 kv. They show that the amount of filtration required to get to the straight portion of the curve decreases rapidly with the voltage. Where high intensity of penetrating radiation is desired, there is, in this last consideration, a strong argument in favor of the use of high voltage. With a 3 mm. copper filter at 298 kv., for example, the penetration, as indicated by the slope of the absorption curve is about the same as with a 6 mm. copper filter at 225 kv. Under these conditions the intensity is seven times as great at the higher voltage. As the milliamperage is the same in both cases, this seven fold increase in *x*-ray intensity has been obtained with an increase of only 32 per cent in the energy supplied to the tube.

The lowest value of the average linear absorption coefficient indicated is 2.31.

This, according to the work of Richtmyer[6], would correspond to a wave-length of 0.072 A°.

M. General Summary of Results

1. A design of *x*-ray tube is shown in Figure 1 which has served for experimental work up to 300,000 volts (max.).

2. This type of tube can apparently best be operated from either a high voltage transformer with mechanical rectifier and resistance control, or from a suitable source of high voltage direct current. (The *x*-ray output and tube behavior with other high tension systems are also discussed.)

3. An experimental interrupterless machine is described which has operated satisfactorily, even in humid summer weather, at voltages up to 300,000.

4. A constant-potential continuous-current machine, for voltages up to 200,000, is described.

5. As measured by the penetration through 10 cm. of water, 200 kv. direct-current excitation is equivalent to 235 kv. (max.) of alternating current excitation. At these voltages the *x*-ray intensities are the same for equal milliamperage.

6. For the medical application, it looks much safer to judge of *x*-ray intensity and quality, from sphere-gap and milliamperemeter measurements of the electrical energy put into the tube rather than from direct measurements made with an ionization chamber.

7. Even when such outwardly different high voltage sources as the transformer with mechanical rectifier on the one hand and the induction coil on the other, are used, the resulting radiations differ in quantity and quality by scarcely more than the experimental error, when the energy input is controlled by a standard sphere-gap and a milliamperemeter.

8. The voltage at the terminals of the *x*-ray tube should be controlled by a voltmeter connected across the low tension side of the high voltage generator, and the low tension voltage required to produce the desired tube voltage should be frequently determined by means of a standard sphere-gap connected in parallel with the tube. This calibration must be made at the exact milliamperage which is to be subsequently employed.

9. For accurate duplication of results, it is desirable that the design of the high tension source shall be such that, for a given high tension voltage, the required primary voltage will not change rapidly with the milliamperage passing through the tube.

10. For the measurement of tube current in therapy, two milliamperemeters should always be used in series with the tube, and they should be occasionally compared with a standard meter.

11. Where an interrupterless machine with resistance control is employed, and the tube filament is heated from the same source of current supply, the milliamperage should be held very constant by a suitable stabilizer, as otherwise line voltage fluctuations will cause marked fluctuations in the high tension voltage, owing to the presence of the resistance in the low tension circuit.

12. At 200,000 volts (max.), with as much as 0.2 mm. of copper filter, different "high voltage" tubes differ but little in output, the average deviation from the mean in a series of twenty tubes being only 1¼ per cent.

13. At 127,000 volts (max.), with as much as 3 mm. of aluminum filter, different "Universal" type tubes differ but little in output, the average deviation from the mean in a series of seventeen tubes being about 3 per cent.

14. Where no filter is used, tubes differ markedly in output, owing to differences in bulb thickness. This would be of no importance in connection with plate density in diagnostic work, in which the patient's body is interposed between tube and plate or tube and screen. It might, however, be quite important in skin therapy with unfiltered radiation.

15. For the therapeutic application, the effect of tungsten deposit on the bulb can apparently be neglected.

16. Bad pitting of the target appreciably reduces the efficiency of a tube in the direction of the central beam. For this reason, therapy tubes should not be used

[6] F. K. Richtmyer, *Phys. Rev.*, N. S., July, 1921, Vol. xviii, No. 1, p. 21.

for radiographic work, in which pitting might occur.

17. Curves are given showing the distribution of *x*-ray intensity in different directions around the focal spot, at voltages of 127,000 and 200,000.

18. The intensity maximum does not lie in the "central beam," but from 10 to 20 degrees away from this towards the heel of the target. (This is probably due, in the main, to the fact that the cathode ray stream does not hold to the axis of the tube, but is electrostatically deflected towards the toe of the target.)

19. In the equatorial plane (about the girdle of the tube), the intensity is essentially constant through an angle of about 100 degrees.

20. The distribution curves for a badly pitted target are also given.

21. Absorption curves are given for copper, extending up to 298 kv. max. They show the attractiveness of high voltage excitation if a considerable intensity of very penetrating radiation is required.

The lowest value of the average linear absorption coefficient indicated is 2.31. This corresponds to a wave-length of 0.072 Å.

THE ULTRAVIOLET RAY IN THE TREATMENT OF ROENTGEN RAY TELANGIECTASIS

BY H. H. HAZEN, M.D.

Professor of Dermatology, Georgetown University, and Howard University

WASHINGTON, D. C.

THE present tendency to use the roentgen ray and radium in many conditions has resulted and will result in various types of sequelae to some patients. One of the most frequent of these unfortunate accidents is the production of telangiectasis. As is well known, this condition may result either from one erythema dose, or more rarely from a number of doses where pigmentation was produced. These marks, at times, are extremely unsightly and are the source of much mental discomfort to those having them. It should be noted that there is always some accompanying atrophy of the glandular structure and of the fibrous tissue of the skin.

In the past there has been no thoroughly satisfactory way of removing these dilated blood-vessels. The electric needle, carbon-dioxide snow and multiple punctures with a galvanocautery have been recommended, but all of these methods leave much to be desired. The well-known effect of the ultraviolet lamp in producing an obliterating endarteritis led me to the employment of the Kromayer lamp in attempting to clear up these telangiectases. MacKee in his recent book, "X-Rays and Radium Treatment of Diseases of the Skin," mentions this method favorably and refers to the work of one or two other authors.

Up to the present time eight lesions have been treated. Three were comparatively small telangiectases due to radium placques, two were large areas covering the whole of the thyroid and thymus areas, and the remainder were mild scattered lesions resulting from one erythema dose in acne.

With an active lamp, using a quartz compression lens, I have found it necessary to give from fifteen to twenty minutes to each area. In no instance have more than two treatments been necessary to obliterate the vessels in the areas so treated. The results are a complete disappearance of the dilated blood-vessels, but naturally the atrophy of the skin remains unchanged and usually the result in appearance is that of a small, slightly whitened scar. However, these results are so encouraging that it seems worth while to record them. It might be added that I am not a great believer in the efficacy of the Kromayer lamp for all skin affections. Practically the only condition in which we have had a high percentage of success with it is the one which I have just mentioned.

BEHAVIOR OF THE STOMACH IN ULCER AND CANCER OF THE DUODENUM BELOW THE BULB*

BY A. W. CRANE, M.D.

KALAMAZOO, MICHIGAN

THE two following cases illustrate the subject of this paper. To arrive at a conclusion regarding the behavior of the stomach in ulcer or cancer of the duodenum below the bulb will, of course, require the experiences of many roentgenologists. These cases are too rare for any one to accumulate a long series, and so I venture to report two carefully studied cases in the hope that others will be added from time to time.

Carman states that less than one in ten of duodenal ulcers are located beyond the bulb. According to our own experience exactly one in a hundred are located beyond the bulb.

Regarding cancer of the duodenum below the bulb, information is still more meagre. Judd in the Mayo Clinic, found five cases of duodenal cancer out of twenty-four cases of cancer of the small intestine, and these twenty-four cases comprised less than 1 per cent of the carcinomas of the gastro-intestinal tract operated upon at the Mayo Clinic. How many of these five cases were beyond the bulb is not given. Carman may be quoted as follows: "Cancer in the supra-ampullary area is not to be differentiated roentgenologically from ulcer. But since it has only been seen five times in four thousand operative cases of duodenal ulcer, a failure to diagnose it should be forgiven. The *x*-ray was used in three of the five cases of carcinoma of the duodenum. In the first one the colon only was examined. In the second case the roentgen findings of the stomach and duodenum were indeterminate. In the third case the finding was duodenal ulcer."

In the two following cases there will be seen a marked difference in the behavior of the stomach between duodenal ulcer and duodenal cancer beyond the bulb. If this difference is found to hold good in a large series of cases then a useful point of diagnosis will have been established.

CASE 1

Patient. W. R. T., Date 7/10/20.

Clinical Diagnosis. Duodenal obstruction. Dental sepsis.

Operative Diagnosis. Encircling cancer of duodenum below the bulb.

Chief Complaints. Epigastric pain. Vomiting.

Symptoms. Onset of present symptoms was six weeks ago. Patient has epigastric pain when stomach is empty. He is most likely to have this pain about 4 P.M., and then on until supper. He may have the pain at night, perhaps twice a week; may have gas on stomach, and belching then gives some relief. Pain is very irregular; he may go several days without pain. Eating gives relief as a rule, but not always. Pain is never made worse by eating. He may have a good appetite, but may feel distended after eating very sparingly. The pain does not strike through to the back but may extend to lower chest. Exertion does not bring on pain, but he is more likely to have attacks when tired.

Soda may give partial relief between meals when gas is belched; at other times alkalies are without benefit. For the last two nights he vomited, each time more than a quart of very sour fluid, with relief. He has no regurgitation; is never jaundiced.

No particular articles of food disagree.

Causes. Unknown to patient.

Personal History. White, age sixty-one, lawyer, married thirty-five years, two healthy children. Habits: Fairly good. Sleeps well, appetite good, no constipation.

Previous Diseases. Injuries. Operations, Never in bed twenty-four hours continuously to his recollection.

Family History. Father died at seventy-six of some kidney disease. Mother died at seventy of heart disease. Three brothers dead, one of kidney disease. Two brothers and one sister living and well.

Previous Treatment. None except in last few days for temporary relief of pain.

PHYSICAL EXAMINATION

No change in appearance, vigor or weight. Negative finding throughout. Blood-pressure

* Read at the Second Annual Midwinter Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY, St. Louis, Mo., Feb. 21, 1921.

S. 125, D. 75. Pulse, temperature and respiration normal.

X-RAY EXAMINATION

Chest. The chest was examined by the fluorescent screen in both the upright and horizontal positions. No abnormalities were discovered.

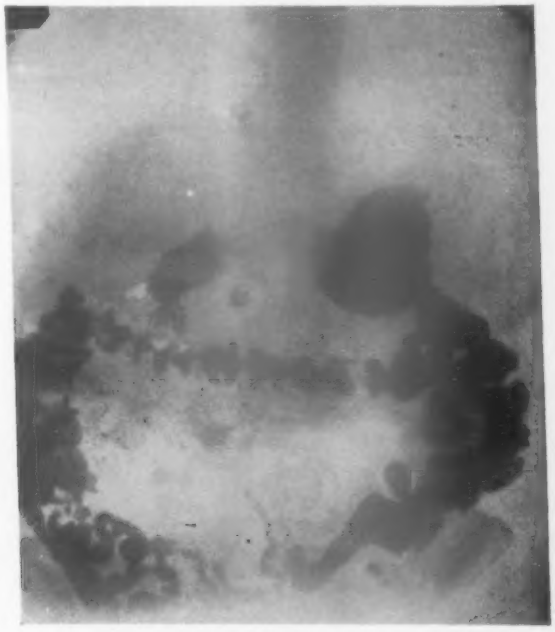
Gastro-intestinal Tract. A glass of barium and water was administered with the patient standing. This passed the esophagus in the usual manner. The filling and unfolding of the stomach showed a moderate ptosis and relaxation. There was but little effort at peristalsis. The barium settled to the lower pole of the stomach, giving the characteristic half-moon appearance seen in cases of obstruction. A plate made in the upright position illustrates these points and shows a single shallow peristaltic wave in the greater curvature. A bubble of trapped gas indicates the approximate location of the duodenal bulb. The indefinite outline of the pyloric antrum of the stomach is suggestive of obstruction.

The first barium meal was administered at 3 P.M. (7/12/20). At 9 A.M. (7/14/20), two days later, there still remained a large gastric residue. A plate made of the abdomen at this time shows also much barium still retained in the small intestines. The colon is fairly well outlined, but not well filled. Another small portion of barium and water was administered to the patient in order to obtain, if possible, a filling of the duodenal bulb. Forty-eight hours later another plate was made of the abdomen. This shows a very large gastric residue, a considerable quantity of barium in the small intestines and a fairly complete filling of the colon.

July 10, 1920, 6 p.m.

CASE I. Carcinoma of the Duodenum below the Bulb. Patient prone.

This plate three hours after the first barium meal shows persistent pyloric closure with inhibition of peristalsis. No barium had escaped from the stomach. Compare with later plates showing gaping pylorus also with inhibited peristalsis and marked retentions.



July 12, 1920, 9 a.m.

CASE I. Carcinoma of the Duodenum beyond the Bulb. Patient prone.

Two days after the first barium meal we find a large gastric residue, a contraction of the antrum, a filled bulb and considerable barium in the colon, showing the absence of a demonstrable obstruction.

Three sets of serial plates were made, each showing four views of the antrum pylori, pylorus and region of the duodenal bulb—the first set on the 10th, the second on the 12th, and the third on the 14th. The first serial plate shows deep laborious peristaltic contractions of the antrum without the expulsion of the barium through the pylorus. This plate was made immediately following the first barium meal. A second serial plate was made following the administration of a very thin mixture of barium and water. This shows an incomplete filling of the duodenal bulb and suggests some deformity of the pylorus. Two days later another thin suspension of barium was given in addition to the gastric residue present and a serial repeated. This shows a

marked distention of the duodenal bulb, such as to overlap and conceal the pylorus. In the plate made of the abdomen preceding the serial plate and also preceding the administration of the thin barium suspension (the third barium meal) the pylorus appears widely open and the absence of an organic obstruction at the pylorus is thus demonstrated. In none of the plates is there a good delineation of the duodenum beyond the duodenal bulb.

A study of the outline of the stomach does not show any filling defect or contracture indicative of gastric ulcer or gastric cancer. On one of the serial plates there is a deformity in the usual outline of the pylorus, but this was not repeated in other plates.

On all of the plates there is seen to be a diminution in the normal size of the liver as estimated by its proportion to the rest of the body. The spleen is somewhat enlarged. There is no enlargement of the head of the pancreas, judging from the position of the duodenal bulb and from a few fragments of the arc of the duodenum.

The retention of barium scattered through the small intestines thirty-six and forty-eight hours after the administration of the barium mixture we would attribute to the slow escape of the barium from the stomach rather than to any affection of the small intestines. The abdomen was palpated beneath the *x*-ray screen. No area of pain on pressure and no abnormality of the colon were thus detected.

No gallstones can be detected on any of the plates. This, of course, does not exclude them, because in the majority of cases gallstones are transparent to the *x*-ray.

Mr. T. was recalled on the 16th and a complete set of tooth films made. These films show a very extensive septic process about five of the teeth.

A fluoroscopic inspection was made of the stomach at this time (7/16/20, 11:45 A.M.). This shows that there is still present a very large gastric residue. This residue has remained since the small water suspension more than two days preceding. Another *x*-ray observation was made 7/19/20 at 11:30 A.M. The plate made at this time shows a massive gastric residue. This residue is present at the end of five days, since the last barium.

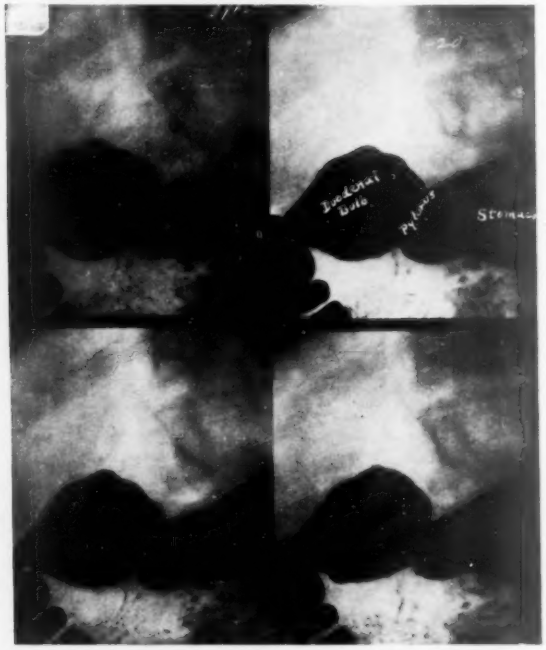
The patient was interviewed on the morning of the 20th and stated that he had had a very bad night with abdominal pain and vomiting.

The foregoing data are given, so far as possible, without personal bias. The follow-

July 14, 1920, 9 a.m.

CASE I. Carcinoma of the Duodenum beyond the Bulb. Patient prone.

Two days after the second barium (suspension) we still find a large gastric residue, an open pylorus, a filled bulb and a delineation of the colon. Pyloric obstruction is excluded by the last two plates.



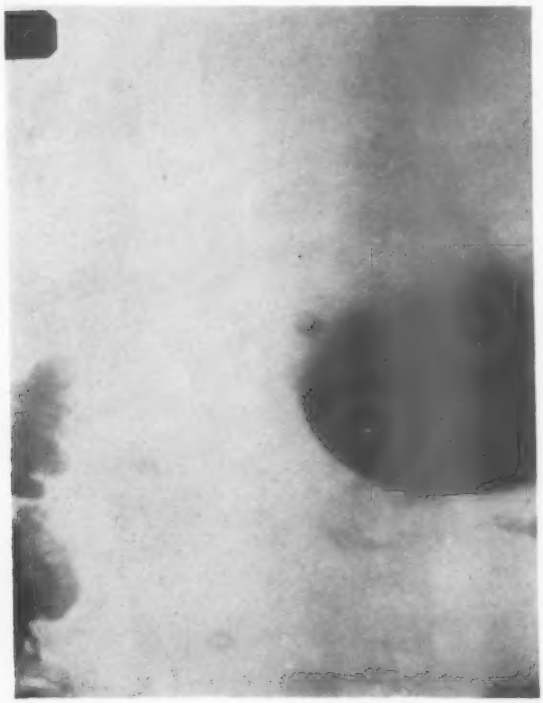
CASE I. Carcinoma of the Duodenum below the Bulb. Patient prone.

This is one of three serial plates showing the absence of a lesion in antrum, pylorus or duodenal bulb. The pylorus is gaping and the bulb distended.

ing recapitulation arranges and interprets this evidence and gives the final conclusions under the head of diagnosis. Excepting for condensation this is substantially the report as sent to the attending physician three months before operation.

RECAPITULATION

Case History. The onset of symptoms is recent. The epigastric pain began six weeks before and the vomiting two days before this examination. The occurrence of the pain is rarely in the morning, usually from 4 P.M. until supper, occasionally at night. The vomiting which occurred each time at night showed a large food retention, but the vomitus was liquid, showing digestion.



CASE I. Carcinoma of the Duodenum below the Bulb. Patient prone.

This plate (7/19/20) shows a massive gastric residue five days after the last barium taken. The quantity is such that the major portion must be due to the only considerable barium meal, which was given eight days and twenty hours preceding.

The appetite is good, but a little food brings a feeling of undue fullness, although eating gives temporary relief from pain. Vomiting has brought temporarily the only complete relief. The patient is more likely to suffer when tired, but exertion is not a factor in the production of his pain.

There is nothing about his habits, previous diseases or family history that appears significant.

Physical Examination. This is negative throughout. Although the epigastrium is the seat of symptom-pain, there is no pressure-pain.

X-Ray Examination. The appearance of the stomach in the upright position is that usually seen in pyloric obstruction. The character of the peristalsis is likewise that of pyloric obstruction:—slow, deep, laborious, ineffectual and finally shallow. But some of the *x*-ray plates show a widely gaping pylorus, the antithesis of obstruction, and also a distended duodenal bulb. Two of the plates indicate closure of the pylorus by spasm. The scattered barium through the small intestines indicates a slow escape of barium from the stomach, and the head of the colon is well outlined by the end of eighteen hours.

It is clear that no pyloric obstruction is present, and yet there was a massive gastric residue at the end of over four days. Two factors are thus probable—pylorospasm, and an obstruction beyond the bulb. A slight deformity of the pylorus on one of the plates suggested ulcer which would explain pylorospasm. There was no demonstration on any plate of a narrowing of the duodenum.

Laboratory Findings. The negative Wassermann helps to confirm the negative history. The normal hemoglobin and red-cell count (for an indoor worker) helps to exclude hemorrhage of any extent. No leukocytosis is present. The differential count is normal.

The urinalysis shows no renal pathology. An excess of indican in one sample calls for repeated examinations.

One half hour after the Ewald test-breakfast of bread and water the Rehfuss fractional tube was passed and five samples of the stomach contents were obtained at fifteen minute intervals. The analyses of these samples show a gastric juice within normal limits. It is noteworthy, however, that in the final sample there is a decided

LABORATORY EXAMINATIONS

(Only those headings which were filled in are given from the laboratory sheet)

Blood:	7–10–20	*Urine:*	7–10–20	7–12–20
Wassermann	Negative	How obtained	Voided	Voided
Hemoglobin	80%	When	P.M.	A.M.
Red-cells, No	4,130,000	Color	Amber	Amber
Microcytes	0	Sp. gravity	1.030	1.028
Megalocytes	0	Sediment %	½%	—¼%
Poikilocytes	0	Character	Nebular	Nebular
Chromatophiles	0	Casts	Few hyaline	0
Normoblasts	0	Pus	x	0
Microblasts	0	Blood	0	0
Megaloblasts	0	Crystals	0	0
White-cells, No	5,100	Other elements	0	0
Lymphocytes	27%	Reaction	Acid	Acid
Mononuclears	2%	Indican	x	xxx
Neutrophiles	69%	Albumin	0	0
Eosinophiles	2%	Sugar	0	0
Basophiles	0%			
Myelocytes	0%			

Stomach Contents:					
Ewald test-meal given at 8:35					
Removed at	9:05	9:20	9:35	9:50	10:05
By Tube?	Yes	Yes	Yes	Yes	Yes
By Vomiting?	No	No	No	No	No
Quantity	36 c.c.	22 c.c.	32 c.c.	38 c.c.	210 c.c.
Gross Appearance	Moderately 3 layers	chymified 2 layers	Mod. chy. 3 layers	Well 3 layers	chymified 3 layers
Color	White	White	White	White	Cream
Mucous	Present	0	Present	0	0
Filtrate	25 c.c.	13 c.c.	23 c.c.	26 c.c.	
Free HCl	4.	12.	14.	18.	24.
Combined HCl	8.	16.	2.	10.	12.
O. A. & A. S.	2.	4.	8.	6.	6.
Total acidity	14.	32.	24.	34.	42.
Lactic acid	0				
Starches	Erythro-dextrin				
Blood	0				
Pus	0				

jump in the per cent of free hydrochloric acid.

Diagnosis. The history of the case is suggestive of a gastric hyperacidity, the analyses of the stomach contents show practically a normal gastric juice excepting for a suggestion of hyperacidity in the final sample. The vomiting of large quantities of sour, watery material is suggestive of some hypersecretion as well as retention. The *x*-ray examination shows pylorospasm and obstruction below the bulb.

One interpretation of this evidence is that the patient has some irritation at the pylorus, possibly a small pyloric ulcer. There is no disease elsewhere in the abdomen which we were able to discover and which we could look upon as a reflex cause of pylorospasm or inhibition of peristalsis. Following the first examination he was advised to take a diet of eggs and milk. It is possible that this diet absorbed the free hydrochloric acid so as to allow a relaxation at the pylorus as seen in later plates. Obstruction beyond the duodenal cap is not, however, explained. If this were due to ulcer we would expect a different type of peristalsis and a different rate of stom-

ach emptying unless the lumen of the duodenum were narrowed by adhesions or scar tissue. There is no preceding history in this case indicative of an involvement which would lead us to expect the presence of either scar tissue or adhesions.

The one finding, therefore, which we may clearly affirm is that we have a marked gastric and duodenal stasis with a suggestion of a partial obstruction beyond the bulb.

The cause of the vomiting appears to be the obstruction and the consequent retention within the stomach. We find no toxic cause of vomiting. The urine does not indicate renal disease. No source of a toxemia was discovered. In one sample of the urine there is an excess of indican. As a rule an excess of indican is associated with a diminution in the hydrochloric acid secretion. With a hyperacidity this has been described as an indication of open ulcer, doubtless because bleeding gives rise to decomposition products and indoxol. No ileostasis can be diagnosticated to account for indicanuria.

The stools have not been examined for occult blood.

Summary. Gastric stasis due to pylorospasm and duodenal obstruction.

Under recommendations for treatment, in view of the carious teeth found by the *x*-ray, we quoted the following from Barclay, "The Alimentary Tract," page 68: "Bad teeth and septic conditions of the mouth, etc., must be attended to before any reliance can be placed on delay in emptying. I have seen a case cured by removal of carious stumps in which a large quantity of food was still present in the stomach after 24 hours. It is probable that sources of irritation lower down in the alimentary tract may also produce spasmodic pyloric obstruction. I believe that these spasmodic contractions are the direct precursors and probable causes of the formation of actual pathological changes in the stomach walls."

The patient obtained no relief from the removal of teeth but refused operation. He underwent medical and dietetic treatment at the hands of several physicians without improvement and finally after a delay of two and a half months decided to go to the Mayo Clinic. The foregoing report of his case which had been sent to his first attending physician he took with him. There he was again thoroughly examined without a more definite diagnosis being found possible. He had now become uremic, but operation was undertaken as an exploratory measure and a last resource. The following extract from a letter to us by Dr. Charles Mayo after the patient's death tells the story:

"When this patient arrived he had only 10 per cent phenolsulphonephthalein output from the kidneys and one day none at all; his blood urea was 125. While he evidently had obstruction, the blood picture showed so badly that it was deemed best to try to improve his condition with salines and rectal feedings, and when the blood urea came under 100 he was to be operated upon. This occurred; but as it did occur Mr. T. developed gastric tetany. While his condition was a desperate one it was then thought advisable to take the chance, small as it was, of making a gastroenterostomy; W. J. Mayo performed the operation and it was recognized that the patient had an encircling cancer of the duodenum just below the common duct and attached to the pancreas; it was probably a primary cancer of the duodenum, a most rare condition."

It may be observed that cancer was not recognized prior to the operation. Obstruction below the bulb was stated as a deduction but was not demonstrated by the preoperative examinations. The pyloric ulcer which we suspected as the cause of pylorospasm was not found by the surgeon, so that it is evident that pylorospasm and a gaping pylorus alternated as a result of the disease below. That food passed the obstruction is shown not only by the barium filling of the colon but by the fact that the patient lived three months after our demonstration of a five-day residu The obstruction was not in itself sufficient to account for a five-day gastric retention. Hence it is probable that the nature of the disease was largely responsible for this retention. It is possible that there was a reverse peristalsis of the duodenum although we did not perceive it. The secretory and peristaltic functions of the stomach were not inhibited at the time

of our examination, and in the absence of a reverse duodenal peristalsis it is difficult to understand how a five-day gastric retention could be maintained.

This case of cancer of the duodenum below the opening of the common duct is in marked contrast with the following case of ulcer of the duodenum also below the common duct.

CASE II

Patient. Mrs. M. T. B. Date 3/24/20.

Clinical Diagnosis. Duodenal ulcer with gastric hyperacidity and anemia.

CASE II. Duodenal Ulcer below the Bulb. Patient standing.

Observe the accumulation of barium in the distended portion of the duodenum. The arrow points to the duodenal constriction.

Operative Diagnosis. Duodenal ulcer.

Chief Complaints. Epigastric pain. Vomiting.

Symptoms. The patient has pain, nausea and epigastric soreness immediately after eating. The epigastric soreness has been constant for the last two years. Her husband states that she has vomited frequently for thirty years. Patient states that she has vomited especially during last two years and has vomited after every meal for the last year. Loss in weight began about two years ago, with a corresponding loss in strength. She thinks she had a "bunch" in upper abdomen which she says is growing and which is sore and painful.

She has headaches more or less constantly since the beginning of the epigastric pain. They extend from neck over left side of head into left eye. During last October she was greatly bloated about the abdomen and lower extremities but was relieved under treatment by digitalis. Eyelids still edematous.

Causes. Unknown to patient.

Personal History. White, age forty-five, married thirty years, two miscarriages, no children. Menses ceased two years ago. Three or more cups of coffee daily, often a bedtime cup. Sleeps poorly. Constipated.

Previous Diseases, Injuries, Operations. Twenty years ago spinal abscess, ill five years, twelve years ago tumor of left ovary removed. In 1920 was three days in hospital for heart disease.

CASE II. Duodenal Ulcer below the Bulb. Patient prone.

Observe dilatation of duodenum without stratification of contents. The arrow points to the duodenal constriction.

Family History. Negative throughout.

Previous Treatment. Much medicine.

PHYSICAL EXAMINATION

Patient appears cachetic and very weak. Pulse 60. Temperature 98° F. Blood-pressure S. 150, D. 0.68. Epigastric soreness very marked and accompanied by muscular rigidity. No "bunch" can be palpated. The rest of the physical examination was negative.

X-RAY EXAMINATION

Chest. The diaphragm action, the lung fields, the heart and great vessels all appear normal.

Gastrointestinal Tract. The contrast meal was given in the upright position. There is a marked gastroptosis. Peristalsis and stomach emptying began in this position. The barium which passed from the stomach collected in a pouch-like formation in the duodenum.

In the horizontal position the area of abdominal pain was carefully palpated. This area was situated a little above and to the right of the stomach without apparent connection with the stomach or with the first portion of the duodenum.

CASE II. Duodenal Ulcer beyond Bulb. Patient prone.

The arrow points to the duodenal constrictions, found to be site of ulcer. Observe dilatation of the proximal duodenum and normal filling beyond point of constriction.

The duodenum appeared very greatly dilated so that in the upright position a portion of the duodenum gave the appearance of a diverticulum. This was not, however, a true diverticulum but an extreme dilatation of the descending portion of the duodenum. The arc of the duodenum was not sufficiently large to indicate an enlargement of the head of the pancreas. A constricted portion of the duodenum was found just at the beginning of the ascending limb, forming an hourglass duodenum. The ampulla of Vater and the first portion of the common duct appeared to fill with barium, doubtless because of the marked distention of the duodenum. The duodenal cap itself appeared normal. The duodenum could be filled to the duodenojejunal flexure without further involvement which was apparent. At the end of five and one-half hours the stomach was empty but the duodenum was still filled with barium. The head of the barium column at this time was in the transverse colon.

On the following morning the colon was practically empty excepting the descending portion and the sigmoid. A second contrast meal was now given and a plate made of the entire abdomen. This shows the stomach situated well to the left of the median line. The pylorus was patulous and the duodenum filled quickly to the point of constriction.

CASE II. Duodenal Ulcer beyond the Bulb. Patient standing.

This plate was one of several taken after a gastroenterostomy, because of the return of symptoms. The anastomosis, indicated by the arrows, is functional. No vicious circle was found. The duodenum could not be filled.

A study of stomach outlines on the various plates and by means of the fluorescent screen in various positions of the body shows no filling defects or contractures indicative of either ulcer or cancer. The pylorus itself and the duodenal cap appear normal. There is no sign on the *x*-ray plates of a tumor. The stomach appears displaced to the left but shows no pressure deformity or filling defect.

There is no enlargement of the liver or spleen. No gall-stones could be found on any of the plates.

The following recapitulation is an arrangement and an interpretation as in the foregoing case.

RECAPITULATION

Case History. The symptoms are, briefly, abdominal pain and vomiting. While the patient has had digestive disturbances with frequent vomiting for the past thirty years, the present symptoms were not constant until two years ago. Since then

LABORATORY EXAMINATIONS

(Only those headings which were filled in are given from the laboratory sheet)

Blood:	3–24–20	*Urine:*	3–24–20	3–25–20	10–6–20
Wassermann	Negative	How obtained	Voided	Voided	Voided
Hemoglobin	73%	When	A.M.	A.M.	A.M.
Red-cells, No	3,760,000	Color	Straw	Straw	Straw
Microcytes	Present	Sq. gravity	1.012	1.014	1.014
Megalocytes	0	Sediment %	−½%	1/10%	¼%
Poikilocytes	Present	Character	Gelatinous	Gelatinous	Nebular
Chromatophiles	0	Casts	0	0	Few hyaline
Normoblasts	0	Pus	Few cells	Small amount	x
Microblasts	0	Blood			0
Megaloblasts	0	Crystals	Oxalate	0	0
White-cells, No	6,700	Other elements	Epithelial cells	Epithelial cells	Epithelial cells
Character	Normal	Reaction	Acid	Acid	Acid
Lymphocytes	24%	Indican	x	x	x
Mononuclears	7%	Albumin	0	0	0
Neutrophiles	66%	Sugar	0	0	0
Eosinophiles	1%				
Basophiles	2%				

Stomach Contents:

Ewald test-meal given at 9:20.

Removed at	9:55	10:10	10:25	10:40	10:55
By tube?	Yes	Yes	Yes	Yes	Yes
By vomiting?	No	No	No	No	No
Quantity	25 c.c.	15 c.c.	9 c.c.	11 c.c.	27 c.c.
Gross Appearance	2 layers	Homogeneous	Homogeneous	Homogeneous	Homogeneous
	Fairly well chymified	Well chymified		Well chymified	
Color	White	Cream	Cream	Cream	Cream
Mucus	0	0	0	0	0
Filtrate	15 cc.	7 c.c.	4 c.c.	4 c.c.	13 c.c.
Free HCl	24.	26.	35.	30.	6.1
Combined HCl	7.				
O.A.&A.S.	4.				
Total acidity	35.	46.	55.	65.5	88.
Lactic acid					0
Starches	Erythrodextrin				Erythrodextrin
Bile					0
Blood					0
Pus					0
Micro-organisms					Cocci & bacilli
Parasites					0
Fecal Matter					0

she has lost steadily in weight and strength. The symptoms have been persistent and progressive so that for the last year she has vomited after every meal. There is also a constant headache varying greatly in severity.

There is a history of an old spinal abscess and of a pelvic operation twelve years ago. Since onset of present symptoms she was successfully treated for a cardiac decompensation.

Physical Examination. Excepting for a cachexia and epigastric soreness the physical examination is negative.

X-Ray Examination. The essential points in the *x*-ray examination are the active gastric peristalsis, the patulous pylorus, the rapid expulsion of stomach contents, the dilatation of the first two-thirds of the duodenum with a filling of the ampulla of Vater, the constriction of the duodenum so as to form a partial obstruction and the coincidence of this construction with the abdominal pain on pressure. The negative findings do not need to be recapitulated.

Laboratory Examination. Blood. This shows an anemia of the secondary type. No leukocytosis is present. The differential count is normal. The Wassermann is negative.

Urine. Three samples were examined without finding evidence of renal pathology.

Stomach Contents. Five fractions were obtained at fifteen-minute-intervals beginning one half hour after the Ewald test breakfast. The analyses of these samples show a hyperacidity in the three final fractions.

Diagnosis. The abdominal pain and vomiting are accounted for by the hour-glass duodenum. The gastric hyperacidity is doubtless a factor in the production of symptoms and makes it probable that the constriction is due to ulcer rather than to adhesions. Cancer as the cause of the obstruction is rendered improbable by the long history of the case, the absence of a palpable tumor and the presence of a constriction instead of a filling defect.

SUMMARY

Our diagnostic findings may be listed as follows:

1. Duodenal ulcer below the bulb producing a stricture of the ascending limb of the duodenum.
2. Distention of ampulla of Vater due to extreme distention of proximal duodenum.
3. Hyperacidity of the gastric juice due to excess of free hydrochloric acid.
4. Secondary anemia.

Subsequent History. Laparotomy was performed and ulceration of duodenum found. A posterior gastroenterostomy was done in the usual way. After a temporary improvement the patient suffered a return of symptoms. An *x*-ray examination showed that the surgical anastomosis was open and that no vicious circle could be demonstrated. The patient refused further surgical treatment. The lapse of eighteen months without the development of cancer confirms the diagnosis of ulcer.

In both of these foregoing cases the chief complaints were epigastric pain and vomiting. In the first case the symptoms were recent—a matter of weeks; in the second case the symptoms were chronic, extending over years. In the first case there was epigastric pain without tenderness, in the second the seat of the epigastric pain was exquisitely tender and the recti rigid.

Unless these cases are exceptional it is probable that very persistent gastric retention is the rule in duodenal carcinoma below the bulb and that rapid expulsion of stomach contents is the rule in duodenal ulcer below the bulb. Duodenal ulcer would thus run true to type whether in the bulb or below, with of course the usual gastric residue in cases of sufficient obstruction or pylorospasm. But the behavior of the stomach in cancer of the duodenum seems in marked contrast to its behavior in cancer of the stomach where rapid emptying is the rule with a gaping pylorus and at the same time feeble peristalsis, excepting, of course, in the presence of a sufficient organic obstruction.

In view of these facts, prolonged gastric retention without signs of gastric, pyloric or bulbar involvement should arouse suspicion of cancer of the duodenum. Also the rapid expulsion of stomach contents without achylia and without bulbar changes should arouse suspicion of ulcer of the duodenum below the bulb.

ACTION OF RADIUM AND THE X-RAYS ON THE BLOOD AND BLOOD-FORMING ORGANS*

BY ISAAC LEVIN, M.D.

The Cancer Division, Montefiore Hospital
NEW YORK

IT is difficult to estimate correctly the mechanism of the action of any agent on the blood and the blood-forming organs. The reason for it lies in the fact that the knowledge of the individual function of the various types of blood-cells and their correlation is quite incomplete. This concerns mainly the types of cells which predominate numerically in the blood, namely, the erythrocytes, the polymorphonuclear neutrophile leucocytes and the lymphocytes.

The numerical proportion of the lymphocytes and the polymorphonuclear leucocytes differs in the various animal species. Of the animals studied by the writer and his associates, the normal blood of a turtle contains less than 10 per cent of polymorphonuclear leucocytes and over 90 per cent of lymphocytes. The blood of a frog contains from 10 to 20 per cent of polymorphonuclear leucocytes, about 80 per cent of lymphocytes and from 2 to 5 per cent of eosinophiles. The blood of a guinea pig contains about 25 per cent of polymorphonuclear leucocytes and 75 per cent of lymphocytes. The rabbit's blood contains both types of white cells in about equal amounts, and the blood of a man contains about 75 per cent of polymorphonuclear leucocytes and 25 per cent of lymphocytes. There is no clear conception as to the functional or embryological reason for this numerical difference in the proportions of the two types of white cells present in the blood of the various species of animals.

Nor is there a complete unanimity as to the influence which radium and *x*-rays exert on these various types of blood-cells. The majority of the investigators however maintain that the erythrocytes present the types of blood-cells most resistant to radiations, while the lymphocytes are the most radio-sensitive cells of any in the organism. The writer has indicated in his previous publications that this "selective" biological action of the rays on the leucocytes goes even beyond the apparent structural differences of the cells. The radiations, for instance, destroy the lymphocytes in lymphatic leukemia a great deal more rapidly than the identical morphological lymphocytes in conditions of inflammatory leucocytosis. As a general rule the action of radium and *x*-rays on the normal blood results in the diminution of the number of lymphocytes and a relative increase in the number of the polymorphonuclear leucocytes.

The influence which radium and the *x*-rays exert on the lymphocytes and on the lymphoid tissue generally, of which the lymphocyte is the most important component part, is of greatest significance in the whole problem of radiotherapy. By increasing the intensity of the radiations it is undoubtedly possible to increase the destructive action on the malignant tumor, but with it goes the danger of a severe injury to the blood and the blood-forming organs. This injury will not only destroy the general resistance of the organism, but will also inhibit the power of the organism to form a protective connective tissue barrier around the tumor. It was stated by the writer on numerous previous occasions that the formation of this connective tissue wall is the most important result produced by radium and *x*-rays on cancer tissue, and this connective tissue formation can only take place when the lymphocytes and the lymphoid tissues of the organism remain intact.

In view of all this it is of great importance to study under different conditions and on different species of animals the action of radium and the *x*-rays on the blood and blood-forming organs.

In a previous publication the writer

* Read at the Sixth Annual Meeting of THE AMERICAN RADIUM SOCIETY, Boston, June 6–7, 1921.

reported upon the action of *x*-rays on the blood of a turtle. Chart I shows the numerical relationship between the polymorphonuclear leucocytes and the lymphocytes before and after *x*-raying.

CHART I

INFLUENCE OF *X*-RAYS ON LYMPHOCYTES OF TURTLE

Smears	Leucocytes	Lymphocytes
Before *x*-ray	3	97
Immediately after	60	40
24 hours later	45	55
96 hours later	45	55
120 hours later	42	58
144 hours later	6	94

Chart I shows the differential count of the blood before the *x*-ray treatment began, immediately after the treatment, and 24 96, 120, and 144 hours later. Numerical relationship between the two types of cells changes greatly soon after radiation, then it gradually returns to the normal, so that 12 days later the blood contains the same relative number of the cells as before radiation.

The present investigation consisted in subjecting to the action of radium and *x*-rays normal frogs and also frogs in whom a change in the white blood cells was induced by a preliminary injection of yeast. A similar study was also undertaken on normal rabbits.

INFLUENCE OF *X*-RAY ON NORMAL FROGS

The experiments were conducted in the following manner. A total and differential blood count of each animal was taken before the treatment. The whole body of the frog was then treated with the *x*-rays for forty-five minutes using a Coolidge tube, 9 in. spark gap, 7 ma., 8 in. focal distance and no filtration. Blood counts were taken at various intervals after radiation for a period of four days. The following results were obtained: The total leucocyte count showed a very slight difference from the normal count before radiation. The differential count showed a marked change in the numerical relationship between the polymorphonuclear leucocytes and the lymphocytes, while the number of the eosinophiles and transitionals remained practically stationary. This change was most marked twenty-four hours after radiation, and the blood usually became normal about four days after radiation. Chart II shows a type of this series of experiments.

CHART II

INFLUENCE OF *X*-RAYS ON NORMAL FROGS

Smears	Lymph.	Poly.	Eosino.
Before *x*-ray treatment	84	14	2
24 hours after treatment	28	70	2

INFLUENCE OF RADIUM EMANATION ON NORMAL FROGS

The method consisted in the introduction into the dorsal lymph-sac of a frog of a minute capillary glass tube about 4 mm. long containing from 1.0 to 0.6 millicuries of radium emanation. This method produces slow and continuous action of the rays of radium on the organism of the animal. The results obtained on the blood were quite analogous to those produced by the *x*-rays. The important difference, however, consisted in the fact that the change in the numerical relationship between the polymorphonuclear leucocytes and the lymphocytes was most pronounced only about three days after the insertion of the radium emanation capillary. Chart III shows a type of this series of experiments.

CHART III

Blood Smears	Lymph.	Poly.	Eosino.
Before treatment	88	10	1
24 hours after insertion of radium emanation capillaries	64	34	2
72 hours after insertion	13	85	2

THE INFLUENCE OF RADIUM AND *X*-RAYS ON YEASTED FROGS

The experiments consisted in the injection of an emulsion of yeast into a normal frog. This injection of yeast is followed by a change in the blood of a frog similar to the one induced by the *x*-rays or radium. This change is most marked twenty-four

hours after the injection and continues for a few days. This series of yeasted frogs was treated by the *x*-rays or radium emanation in the same manner as the first and second series reported above. Now the remarkable phenomenon observed in this series consisted in the fact that neither the *x*-rays nor the radium produced any further noticeable change in the numerical relationship between the polymorphonuclear leucocytes and the lymphocytes, or at the most a very slight additional decrease of the number of lymphocytes. Chart IV presents a type of this series of experiments.

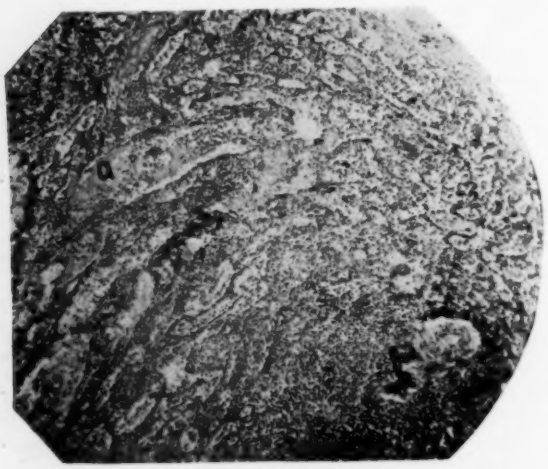


FIG. 1. Shows an area of necrosis at *a* and an altered blood-vessel at *b*.

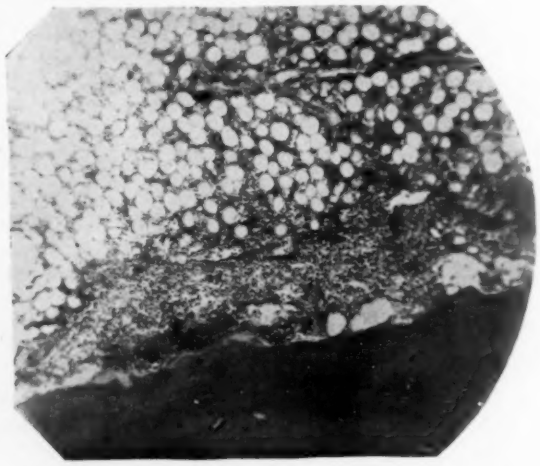


FIG. 2. Shows compact bone necrosis and alteration of bone-marrow.

CHART IV

Blood Smears	Lymph.	Poly.	Eosino.
Before yeasting.....	76	22	2
17 hours after yeasting...	40	60	0
Immediately *x*-rayed and blood tested.....	29	68	3
24 hours later.....	19	80	1

THE INFLUENCE OF THE *X*-RAYS AND RADIUM ON NORMAL RABBITS

Normal rabbits were *x*-rayed with the same technique as was reported above for normal frogs. The whole body of the animal was *x*-rayed. The total leucocyte count again showed only a slight difference from the normal count before radiation. The change in the numerical relationship of the polymorphonuclear leucocytes and the lymphocytes was similar to those observed in the turtles and frogs. The blood-picture became normal again in about three to four days after radiation.

The radium applications in the rabbit were done in the following manner: A laparotomy was performed and from two to four radium emanation capillaries were inserted into the spleen. Blood examination was done before the operation and then was repeated daily for a week after the operation. In no animal was there any change noted in the blood structure. The spleen itself showed necrosis and extravasation and endarteritic changes in the walls of the blood-vessels. Figure 1 shows an area of necrosis and a cross section of an altered blood-vessel. All these changes were found in a small area surrounding the region into which capillary was placed. At a further distance from the capillary the structure of the spleen appeared to be normal. In another series of rabbits an opening was drilled into the shaft of the long bone and two or four radium emanation capillaries were placed into the bone marrow, the opening in the bone sealed with surgical wax and the skin opening sutured. All the operations on the rabbits were done under ether anesthesia. The blood of the animals was examined before the operation and daily for a week after

the operation. Again no change was noted in the blood structure. The marrow surrounding the capillary showed changes similar to those found in the spleen. Figure 2 shows an area of bone necrosis and altered bone marrow.

CONCLUSIONS

The results of the analysis of the experiments of this investigation tend to confirm the prevailing opinion that the lymphocyte is the most radio-sensitive cell in the animal organism. The change in the numerical relationship of the two types of white cells was not accompanied by a noticeable change in the total leucocyte count. Apparently the mechanism of the action of the rays on the leucocytes of the blood consists in the destruction of the lymphocytes, which is then followed by the release of the polymorphonuclear leucocytes from the bone marrow or by an overproduction of this type of cells by the blood-forming organs.

Certain investigators maintain that the polymorphonuclear leucocytes are the type of the blood-cells most readily destroyed by the rays. However, the analysis of their results shows that the destruction of the polymorphonuclear leucocytes only takes place as the final result of the action of a lethal dose of the rays which produces ultimately a severe general leucopenia. The following instance from a publication of Zoellner illustrates the point. The blood of a guinea pig before radiation showed 85 per cent of lymphocytes and 15 per cent of polymorphonuclear leucocytes, two days after radiation it showed 46 per cent of lymphocytes and 54 per cent of polymorphonuclear leucocytes, and three days after radiation 24 per cent of lymphocytes and 76 per cent of polymorphonuclear leucocytes. The total blood count was not changed perceptibly all this time. Since the animals received a lethal dose of radiation, there developed near death a severe leucopenia of from 12,000 to about 600 white cells, so that the whole blood smear showed one or two lymphocytes and no polymorphonuclear leucocytes.

In the present investigation, however, only such amounts of radium and *x*-ray were given that the animals could completely recover after the lapse of a certain time and the blood picture again became normal. The most important phenomenon observed in the course of this study is the difference with which the two species of animals, the frog and the rabbit, react to the action of radium and the *x*-rays. In the frog the same general effect was obtained on the blood by the amount of *x*-raying employed in this investigation, as well as by the insertion of a glass capillary containing 1.0 to 9.6 millicuries of radium emanation. The blood of the rabbits reacted to the *x*-rays in a manner identical with that of the frog. On the other hand, an insertion into the spleen or the bone marrow of a rabbit of 2 or 4 capillaries, *i.e.*, two or four times the amount of radium emanation inserted into the frogs, produced no change in the blood of the rabbit, though it produced marked local effect on the spleen and bone marrow. These comparative findings in the two species of animals and the two types of radiation are of considerable importance to the subject of radiotherapy from two following standpoints:

The subjects of the relative therapeutic efficiency of radium and *x*-rays, of the higher or lower voltage of the electric current producing the *x*-rays, of the correct methods of physical measurement of the rays, whether photographic or ionization methods, for instance, and the correct amounts to be used, are in the order of the day. However, these subjects are treated chiefly from the standpoint of physics rather than from that of biology. There cannot be any doubt that measured by photographic or ionization methods or generally considered from its physical aspect one *x*-ray application as employed in the present investigation and one capillary tube containing 1.0 or less millicurie of radium emanation inserted into the frog and left there to decay represent two qualitatively and quantitatively different entities. Nevertheless they must be considered quite analogous biologically, since they produce the identical effect on the blood of the frogs. This indicated clearly that for biology and medicine a biological standard of measurement would be of far

greater value than the physical methods. It may be added here in parenthesis that the action of the rays on normal blood and lymphoid tissue is of greater importance than their action on the skin, the more so that the radium and *x*-ray burns are most probably due to change in the lymphoid tissues of the walls of the blood-vessels.

The second phenomenon observed in this investigation further illustrates the importance of the biological differences for the ultimate results of the action of the rays. The *x*-rays produced a change in the blood-picture of the rabbit because the square surface of its body is greater than that of the frog, and consequently the former received a greater amount of radiation though all the other conditions of the *x*-ray apparatus were the same as those used in the frog. The radium emanation tubes produced no change in the blood of the rabbit, though the amount was more than sufficient to produce a change in the blood of the frog. The reason for it lies in the fact that the effect is distributed in the larger quantity of the blood of the rabbit and becomes so small as not to be perceptible. At the same time the local effect of the radium emanation is very marked.

Two conclusions may thus be drawn from the analysis of the experiments. First, that radium, as compared with *x*-rays, will produce the same and even a more marked local effect with far less general disturbance of the blood. Second, that the larger the square surface of the entry of the *x*-rays into the organism the more severe is the general effect on the blood. In view of all this, biological conditions must be studied at least as much as the purely physical conditions before a true estimation of both the correct quantity and the quality of the radiations to be used in therapy will be obtained.

DISCUSSION

Dr. Henry Schmitz. In the first place, it has always seemed to me the more anatomy a surgeon knows the better surgeon he is. In the second place, the more physics a radiologist knows the better radiologist he is. I make these statements so that you will not give up your interest in physics and go back to the old days when radiology was not a science at all.

One question I wish to ask is whether the total number of blood corpuscles in the cu. mm. in these animals has been counted and what the proportion is. If an actual decrease in the total number of corpuscles has occurred, then I will admit the differential count, but if the total number of white corpuscles in a cu. mm. remains the same, then it is only a temporary affair and has no real effect upon the condition at all.

I wish to get nearer to a point of such great interest in studying the changes which occur in the blood, in order to see whether they give us any explanation of the sickness that occurs after raying. Possibly Dr. Levin can give us some information on these points.

Mr. Gioacchino Failla. I find Dr. Levin's experiments very interesting and I am glad they will be in the literature, so that, as we know more about the effects of radiation on the blood-forming organs, the biologist and the physicist working together can find the correct explanation of the results obtained. I know that Dr. Levin is a good scientist, and, as a good scientist, he will change his ideas about radiation as he acquires further knowledge. This morning I was pleased to see Dr. Levin show a specimen illustrating the effects of emanation tubes embedded in tissue. About eighteen months ago I spoke to Dr. Levin about this method of treatment, but at that time he was very much opposed to it. Since then, however, he has had more experience and has come to the conclusion that the method is not so bad.

TREATMENT OF GLANDULAR METASTASES OF CARCINOMA*

BY RUSSELL H. BOGGS, M.D.

PITTSBURGH, PENNSYLVANIA

WHEN the program committee requested me to discuss the treatment of glandular metastases, I do not believe they realized what a difficult subject it is at the present time, because there are so many methods of employing radium and the roentgen rays, and naturally the results vary accordingly. At present there are those who advocate very high penetrating, heavy filtered roentgen rays alone, others radium alone, and still others advise a combination of both agents. There is still much to be done by physicists, radiologists and biologists.

The three most important factors to be considered in the treatment of metastatic glands are: first, the situation, extent and depth of the disease; second, the amount of cross-firing necessary to make up for the loss of energy by divergence and absorption of the rays in the tissues; and third, the ratio between the erythema and lethal dose in malignancy.

It is known clinically what glands usually metastasize first in carcinoma of the various organs of the body, and by studying anatomy a chart can be made showing the exact location of the lymphatic vessels and glands. The extent of involvement usually depends on the stage of the disease, but there is no method by which we are able to determine whether metastases have taken place in a lymphatic chain or not. The size of the lesion and its duration are not dependable in giving a prognosis or determining the extent of metastases. When the glands of one lymphatic chain are palpably enlarged, the next chain is nearly always microscopically involved. This has been given very little consideration until lately, and most surgeons, when they operate, consider the palpable glands rather than those that are microscopically involved at the time of operation, although the surgeons have realized for years that, when all the palpable lymphatics have been removed, there usually are cancer cells left behind on account of the number of cancer deaths that follow the most careful glandular dissection. Likewise, most radiologists have not given this part of therapy sufficient attention.

Metastasis is the spread of disease from one part of the body to another and is the natural way by which a cancerous growth progresses, while a recurrence is the return of the malignant process in the vicinity of the primary growth. The two terms should not be used synonymously, as it leads to confusion. Post-radiation is usually given to destroy metastatic cancer cells left after operation rather than to prevent a recurrence, and it is oftener the metastases which kill the patient.

When the cancer cells escape from the primary growth into the lymphatic vessels, these cells may become lodged in the lymphatic vessels, proliferate and form a secondary growth, or are carried by the lymph stream to the lymphatic glands. Many consider that the lymphatic glands act as a filter for a time in preventing the spread of the disease. In the lymphatic glands the cancer cells may be destroyed or may proliferate and produce a secondary growth or metastasis. The regularity with which the lymphatic nodes are involved at some stage of carcinoma makes it imperative that all the lymphatic system adjacent to a primary growth should be rayed. In some cases the first chain of glands is not involved, but glands further distant may contain cancer cells. The question in such instances is, "Do the cancer cells pass through the first set of glands and are they checked by the second?" The more probable explanation is that the cancer cells are carried around the first set of glands by the lymphatic vessels and are deposited in a second chain. It is our aim in every

*Read at the Sixth Annual Meeting of THE AMERICAN RADIUM SOCIETY, Boston, June 6–7, 1921.

case of carcinoma to check cell proliferation and destroy all infected cells by radium and *x*-ray, not only in the primary growth, but in the lymphatic system, as soon as possible. If cell proliferation is allowed to go on and metastasis to become general, serous cavities may be invaded and the disease may even be spread later by the vascular system to the various parts of the body.

The intimate relation between carcinoma and the lymphatics has been carefully studied, and it is essential that the radiologists should know the modes of extension or paths of dissemination. By continuous extension of cancer cells of the primary infiltrating tumor through the lymphatics, metastasis appears at points widely distant from the original growth. The frequency of lymphatic metastasis varies with different types of tumors and with different locations of the same kind of tumors.

Handley's study of mammary carcinoma and metastasis has been very valuable to both the surgeon and radiotherapeutist and will apply to metastasis of any other organ. Ewing has summed up Handley's conclusion in the following paragraph:

"In cancer of the breast Handley has shown that there may be continuous extension of tumor cells through the lymphatics of the deep pectoral fascia to the axillary and supraclavicular nodes; thence to overlying skin and to humerus; through the deep lymphatics to the ribs, pleura, lung and spine; across the chest wall to the opposite breast; downward through the abdominal wall to the epigastric region and thence by the falciform ligament to the liver; and further to the inguinal region with the involvement of lymph-nodes, skin and femur. Extension through superficial lymphatics is much less wide. Invasion of the humerus occurs at the deltoid insertion and of femur at the trochanter, where these bones are closest to the skin, through the deep lymphatics of which the bone invasion follows. The leg and arm bones escape infection, which is inconsistent with a free embolic origin through the blood-vessels. Passing through the deep lymphatics of chest or abdominal wall, the cells enter the pleura and peritoneum and become implanted on the serous surfaces and produce superficial infiltrations of the lungs, liver, intestines and ovary. Or the viscera may be invaded through their main lymphatic vessels giving central tumors. The liver is involved through the lymphatics of the falciform and round ligaments, or by transperitoneal implantation, or by way of portal nodes; the lung by transpleural implantation or through bronchial nodes and hilus. Abdominal invasion by the epigastric route is earlier and more frequent than the thoracic, occurring without thoracic lesions in 12 per cent of all cases. The diaphragm is invaded by the epigastric peritoneal route, and through the descending lymphatics of its crura the retroperitoneal nodes and kidneys are attacked. This process of lymphatics permeation Handley believes is the master process of general dissemination in cancer. Lymphatic embolism he would reduce to a very secondary factor. Handley bases his conclusions on the study of long slices of thoracic and abdominal parietes in advanced cases of mammary cancer. In such material he finds the lymphatics continuously filled by tumor-cells. The only breaks occur as the result of perilymphatic fibrosis, an inflammatory reaction excited by the tumor process and resulting in complete atrophy of tumor-cell cords at many points."

In line with Ewing's statements, it is just as important for the radiologist to know what glands drain each area in the mouth and throat, and the manner in which metastases take place. The lymphatic glands in the neck are closely connected, and those of one side of the neck anastomose with the other. The lymphatics draining the lip are submental and receive the vessels from the central portion of the lower lip, chin and floor of the mouth. The submaxillary, consisting of five or six glands, drain the lateral halves of the lip, the cheek, part of the tongue and lower portion of the nose. There is an anastomosis between the submaxillary glands of each side and the submental, and when one group is invaded, it is only a short time until metastases spread to the next chain. There are from twenty to thirty important cervical glands extending from the mastoid

process to the junction of the subclavian and jugular veins. There are two main lymphatic chains which are connected with the tongue; the submucous, and the intra-muscular. The lymphatics from the tips of the tongue pass to the submental and the inferior cervical; those from the lateral border terminate in the submaxillary salivary glands and some pass directly into the deep cervical, while most of those in the posterior part of the tongue enter a group of glands lying between the large vessels and the parotid glands, and another group of vessels pass into the submaxillary. The vessels passing from the tongue are closely connected with glands of both sides of the neck.

Metastases into the pelvic lymphatics have been studied by many observers and it has been shown that the period of invasion varies greatly with the location and type of disease. It is relatively early in cervical carcinoma and late in carcinoma of the fundus. It has also been shown that there is much variation in the course of the involvement of the lymphatics. Recent studies show that in from 30 to 50 per cent of early cases of cancer of the cervix, the disease has formed metastases into the lymphatics and about 40 per cent of the late cases of the pelvic glands have been found to be entirely free from metastases. This makes it impossible to give a prognosis from a pelvic examination, from tissues removed at the time of operation, or even by a pathological examination. Then the entire glandular system draining and anastomosing with the uterus should be treated by modern radiation; that is, with radium applied locally and either radium packs or deep roentgenotherapy from the outside in every case of cancer of the cervix regardless of the stage of the disease. This means a more extensive raying than the glands in the parametrium, broad ligaments, those situated along the sacro-uterine ligaments, around the rectum and in front of the sacrum, because when these glands contain cancer cells, it is only a short time until the abdominal lymphatics metastasize. Later the liver and lungs metastasize and finally the bone becomes involved.

There is no universal method of raying metastatic glands. Some therapeutists use large areas with very little cross-firing; some cross-fire from every possible angle, using small ports of entry; some imbed radium, and others use large quantities of radium placed on a pack covering a large skin area, while many use a combination or a modification of these methods. There is a wide variation in filtration, spark gap, tube distance and the time of exposure in roentgentherapy, the same as there are great variations in the methods of applying radium. Then, would it not be conceit on the part of any radiotherapeutist to say that his technique is absolutely correct? All have the same object—that is, to give a lethal dose to all the glands which have metastasized. However, it is true that, with all these variations, in the selection of radiation and the different methods of technique, many are producing similar results because these radiotherapeutists know dosage, the difference between skin dosage and depth dosage and the difference between a lethal dose and an erythema dose, and know what should be expected in a given case coming for treatment.

The method of treating deep metastatic glands by the *x*-ray until the last year was by using many ports of entry and cross-firing as much as possible. The equation ordinarily used was nine-inch spark gap, 5 ma., eight-inch tube distance, and filtered through from 4 to 10 mm. of aluminum, time of exposure from seven to thirty minutes depending upon the rest of the equation. With this equation it had been calculated that at a depth of four inches from the surface of the skin from six-sevenths to eight-ninths of the radiation was lost by absorption in the tissues and divergence of the rays, the registered radiation being from one-seventh to one-ninth. This included both the direct and scattered radiation and was measured by placing pastilles in the vagina. Then after the lethal dose was determined, the number of ports of entry was figured out. Of course, this data was obtained by a chemical process and was not exactly the same as if it had been worked out by the use of ionometric measurements.

About a year ago it was learned that

the Germans were employing very large ports of entry, higher voltage, more filtration and greater tube distance. They claimed that by the use of larger ports of entry, more scattered or secondary radiation was obtained. At the Freiburg Clinic, they employed a spark gap of 40 cm., tube distance, 30 cm., filtration 1 mm. of copper or its equivalent, 18 mm. of aluminum, using as large a port of entry as possible over the anterior part of the abdomen, and the time of exposure was about three hours. The dosage was measured by a Wulf electrometer. This measured at 10 cm. depth, the calculated dose is 8.4 per cent, while the measured dose was 31 per cent. This considerable difference depends on the secondary or scattered radiation coming from the tissues, the primary radiation only representing about 30 to 40 per cent of the radiation registered by the iontoquantimeter. This created considerable excitement among the radiologists and physicists and many extravagant statements were made. It started the manufacturers to investigate and to work on improving the entire therapeutic outfit, something which had been badly needed.

At the Erlangen Clinic, Seitz and Wintz used a spark gap of 30 to 40 cm., filtered through $\frac{5}{10}$ mm. of zinc (which is equal to 11 mm. of aluminum), tube distance 23 cm., and with a port of entry 6×8 cm. They found that a dose received at a depth of 10 cm., or four inches, is about 20 per cent of the surface dose, meaning registered dose. In cancer of the cervix, they used three ports anteriorly and three posteriorly and a seventh through the vulvular region. Through these seven ports they claim 110 per cent of the skin dosage. Seitz and Wintz's technique is somewhat similar to that which we had been using for some time. The principal difference was that we use more ports of entry, using twelve anteriorly, twelve posteriorly, three right and three left lateral. Then large doses of radium were used locally. For the past two years I have been using 10 mm. of aluminum. It seems that since Seitz and Wintz directed the rays through relatively small skin area to the cervix many abdominal glands were omitted. It seems that some of us in this country have produced about the same end results which they have reported in carcinoma of the uterus, when we used large doses of radium locally, supplemented by deep therapy. In treating glands in the neck and chest our technique has been about the same, except smaller ports of entry were used.

Imbedding radium has many points of advantage in the treatment of carcinomatous growths as well as in the treatment of metastatic glands. It is particularly valuable in malignancy of the mouth and throat following surface applications. Cancer cells located in the sublingual, submaxillary, submental, parotid and cervical glands can be successfully destroyed in more advanced cases than can be removed by surgery, without producing any deformity. In carcinoma of the breast, imbedding radium is a valuable addition to surface applications of radium and the *x*-ray. Thirty to thirty-five 10 mg. needles imbedded in the breast, in the axilla and in the tissues between the breast and the axilla and beneath the clavicle, has more effect than a gram of radium on the surface, because it is more efficient and can be given after the overlying skin has received all the radiation it will tolerate. When radium is buried, surface raying should always be given before and after. It is a valuable method as an ante-operative procedure.

A physician or surgeon cannot do or direct radiotherapeutic work unless he has studied both radium and the *x*-ray from A to Z, the response of different tissues both healthy and diseased, and realizes that the patient dies from metastases, not the local disease. There are many methods by which primary carcinoma can be successfully treated, but there is no positive method by which extensive metastases can be eradicated or cured. Radiation is the only procedure which offers anything when more than one chain of lymphatics are involved, even microscopically.

In the treatment of metastatic glands, the most efficient method is one by which the largest amount of radiation will reach all cancerous cells with the least injury to the skin and overlying structures.

The most disappointing feature of the reports from the German literature is that

they speak of an erythema dose, and state that even less than an erythema dose will destroy all cancerous cells. I am sure that they are wrong because the erythema dose is not always the lethal dose for every type of carcinoma; and if their clinical reports are correct, then we must attribute it to their giving the entire treatment in one day. Now, this does not seem reasonable if you study the cases which we have treated during the past eight or ten years, because we certainly did produce results with the old induction coil using about 1 ma. of current, no filtration, and a spark gap of about six or seven inches, and the erythema dose was given in fractional doses within three weeks. Of course, we all realize that these results were more superficial, and were not equal to those of to-day, but it can be positively stated that cancer cells can be killed by the fractional method. This might be compared to the imbedding of radium emanation which acts on the cancerous tissues for a period of thirty days. The results produced by emanation, so distributed through a cancerous mass acting for thirty days, produces about the same results as imbedding radium steel needles for a few hours. However, this is a question still under controversy.

A large amount of radiotherapy is given by unqualified radiologists. The dermatologist claims that he only intends to treat superficial cancers, then he would be only treating a few superficial epitheliomas around the eyelid and upper part of the face. Lower lip epitheliomas come under deep therapy and very deep at that; the surgeon claims breast carcinoma until it is hopeless; and as a rule when ante- and postoperative treatment is given, many lymphatic glands are omitted and usually a lethal dose is not given. Many of the gynecologists use 50 to 100 mg. of radium locally, and usually no radiation is given to the metastatic glands.

DISCUSSION OF R. B. WILSEY'S "THE EFFICIENCY OF THE BUCKY DIAPHRAGM PRINCIPLE"*

DR. POTTER. I was very much interested in getting these reports of Mr. Wilsey because they showed what we knew before in a general way. They showed it in a very intelligible and scientific way. We knew there were a heap of rays suppressed by these secondary and scattered rays—now we know it is 85 or 90 per cent cut off. We knew we lost definition when the grid was a long way from the plate. He shows just how much we did lose. In other words, he shows exactly those points which we now can build on to improve this little instrument so that it will be at the maximum of its efficiency. I did not say much about it until I was satisfied that the thing was about right. I never could go along and give percentages on this sort of thing. I made very lengthy qualitative experiments where you can estimate in a rough way with a string of plates just how much was cleaned up. Seventy-five per cent was my guess. Glad to hear Mr. Wilsey's estimate is 83 per cent.

DR. PARISEAU. I would like to ask a question of Mr. Wilsey, Dr. Potter, or any members present who have had large experience with the Potter-Bucky diaphragm. I have had one since it has been on the market and I could not dispense with it. On one point at least I was very disappointed. My gall-bladder work was poor through faulty technique and through inherent effects of the method of examination, and I thought I would improve it considerably by the Potter-Bucky diaphragm. In looking over my gall-bladder plates made with the diaphragm and without the diaphragm, using duplitized film or plate and screen, I found that I actually visualized the gall-bladder oftener by the ordinary straight method than with the diaphragm. There is no doubt that the Potter-Bucky diaphragm differentiates very much better than the ordinary plate, so why were my results not better? I think the only possible explanation is this: In any case where movements are to be avoided, the lengthened exposure necessary in the Potter-Bucky diaphragm actually annuls any gain that you make in definition. I do not know whether I am right. I have come to the conclusion of Dr. George in his book that the Potter-Bucky diaphragm for gall-bladder work, in general, is of very little use. The lengthened exposure more than annuls any gain that we may have both in contrast and definition. I would like to know if the experience of members here has not been that for gall-bladder work, where suspended

* This article appeared in the January number.

respiration is absolutely essential, they have not had better results with the straight screen and plate than with the diaphragm.

The cross-grid type—not above the subject but under the subject—was used in France as far back as 1916. It is a cross-grid flap that passes under the patient and is extremely convenient in many ways because it is thin. My actual experience is that as far back as 1916 the cross-grid was not only tried in France, but sold. They called it the "anti-diffuser" which defines it. I would like to hear the experiences of others.

Dr. Pirie. Mr. Wilsey mentioned that if you cut down the diaphragm and make a picture 3" in diameter you get as good results. Acting from that principle I used to take spines this way. What I did was to have a moving diaphragm above the tube and a piece of lead which went slowly across the tube; and for taking spines I found it increased the detail very much. However, it increased the length of exposure so much that I gave it up. It improved the spine pictures very much ten years ago.

Dr. LeWald. I would like to answer in my small way Dr. Pariseau's question. There is no question in my mind that the Potter-Bucky diaphragm aids very materially in diagnosing gall-bladder lesions. I would like to ask Mr. Wilsey if there is enough advantage to use the combination of cone with the diaphragm.

Mr. Wilsey (in closing discussion). I appreciate very much Dr. Potter's kind remarks. It is gratifying to know that these results substantiate the results obtained by him in his series of experiments. Regarding gall-stone technique, I would hesitate to make any suggestions; not being a roentgenologist and being only a physicist I can only investigate and report upon the physical factors involved. When it comes to the practical application of these, you have in your work motion of the patient and other factors which must be taken into account. The roentgenologist must take this information and apply it with his own knowledge and determine what is the best technique to obtain the best results. I feel sure that if the diaphragm is altered in the way suggested by making the slit more shallow, definition will be much improved.

Dr. Cole has done a great deal of work with the double slot method and undoubtedly it would have many advantages. Whether it is superior to the Potter-Bucky diaphragm, I have no measurements to determine. One thing it prevents—scattered radiations being thrown off. By using the slit and slot both below and above the patient, the effect of scattered radiation from the patient is eliminated.

I doubt very much if there is any appreciable advantage in using the combination cone above. The advantage of the cone used by itself, without the diaphragm, is to diminish the distance between the film and the patient. If you use the diaphragm, the cone on top will not help a great deal.

Another point which I would like to bring out is the suggestion of Mr. Van Allen regarding the use of curved cassettes which brings the patient nearer the film and gives equal definition on the whole roentgenogram.

THE AMERICAN JOURNAL OF ROENTGENOLOGY
Editor: H. M. IMBODEN, M.D.
Associate Editors: JAMES T. CASE, M.D. H. K. PANCOAST, M.D. J. S. SHEARER, PH.D.
Publisher: PAUL B. HOEBER, NEW YORK

Issued Monthly. Subscription, $6.00 per year. Advertising rates submitted on application. Editorial office, 480 Park Avenue, New York. Office of publication, 67-69 East 59th Street, New York.

Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

DR. JAMES G. VAN ZWALUWENBURG

James G. Van Zwaluwenburg, Professor of Roentgenology at the University of Michigan, died of pneumonia in the University Hospital, after a week's illness, January 5th, 1922. He was born on May 5th, 1874, in Ottawa County, Michigan, and was thus forty-seven years of age. He was a student at Hope College, Holland, Michigan, from 1889 to 1894, and remained there in 1895 as a teacher of chemistry until he entered the University as a sophomore in the same year. He was graduated in 1898 with the degree of Bachelor of Science. For the next five years he was associated with his brother in chemical work. In 1903 he entered the Medical Department at the University and graduated in 1907.

He was by nature a teacher. Before graduation he served as a demonstrator of anatomy and after graduation remained in the University as Instructor in Internal Medicine until 1910. He then became especially interested in *x*-ray work and was given the task of building a department of roentgenology in the medical school. In 1913 he was made an Associate Professor of Roentgenology, and in 1917 full professor.

His professional life in brief is thus seen to be an orderly development. He was singularly well qualified by temperament and education for the career of a professor and a roentgenologist. His interests from the time of his first college work are seen clearly to be pedagogical and scientific. He entered the *x*-ray field only after a prolonged training in the department of internal medicine, which is incomparably the best training for a roentgenologist. During his period of service in this department he was carefully drilled in medical research and collaborated with Professor Hewlett in the publication of much experimental work.

In this work, was developed a naturally quick and keen perception, a genius for invention, and the clever adaptation of instrumental means to experimental ends, an insight into the classification of data and the evaluation of scientific evidence, and finally the power to correlate apparently unrelated facts and give them coherent expression—all of which characterized his later work in roentgenology to the admiration and despair of his confrères. These faculties were activated by an unquenchable enthusiasm and an industry that taxed the utmost resources of his strength.

Dr. "Van" had reached a point in his work when accumulated data permitted literary presentation. There was of necessity a period of years during which he must gain experience and learn to classify the immense diagnostic material which flowed in ever increasing volume into the department of roentgenology. By well planned organization and capable assistants he had relieved himself of most if not all of the technical work, so that he could give his undivided attention to the interpretation of cases, to teaching, to improvements of methods and apparatus and to the writing of papers and books. Those of his friends who have penetrated to his sanctuary, the "workshop," know something of what the world of roentgenology has lost by his premature death. The meaning that lies locked upon those shelves of plates and records could yield only to the key of the master of the shop. It is melancholy proof of the point which he had reached in his career that his last act, shortly before his final illness, was to block out a book on pelvic pneumoperitoneum and to write a portion of the preface.

His literary remains are nevertheless considerable and of genuine value. The complete list which is appended, was kindly furnished me by Dr. S. W. Donaldson, acting head of the Department of Roentgenology. He added something to every subject that he touched. His discovery and study of the pleural cap would alone preserve his memory to future generations of roentgenologists. The full value of his work upon the heart is not yet fully appreciated.

His work in pelvic pneumoperitoneum, which was carried on with the cordial and able collaboration of Prof. Reuben Peterson, displayed his capacity for original and practical research. So sure and complete was his grasp of both technique and interpretation of plates that his methods have virtually fixed the mode of procedure of this most important application of the *x*-ray in gynecology.

His influence upon his pupils was notable. His power as a professor lay not only in his mastery of the art of roentgenology and his extraordinary knowledge of that expanding science, but also in that gift of inspiring the student mind with something of his own enthusiasm, which is the mark of a true teacher. Another attribute which was beyond price to the school in which he held his chair was his unfaltering loyalty to the University. His hopes, his career, his personal fortunes, were cast with his beloved school without reservations. This was tested by his refusal to enter lucrative private practice in a large city with famous and congenial partners. He chose the laborious life of a scantily paid professor among his students and fellow teachers under the mantle of the great University to which he gave his life.

What his fellow professors on the medical faculty thought of Dr. Van Zwaluwenburg is thus set forth with an eloquent affection by Dr. Hugh Cabot, Dean of the Medical Department:

"In the death of Dr. 'Van' the University has lost an invaluable servant, science has lost an important exponent, and the world has lost a great man. In his work he demonstrated integrity to a very high degree. Utter self-forgetfulness was his, even to excess, and the only thing he ever neglected was himself.

"His capacity for organization and his knowledge of business methods were of a grade rarely found in medical men. His previous training as a chemical engineer gave him a broader outlook than is commonly found in medical specialists. Of his scientific work in roentgenology it would be difficult to speak too highly, though his actual publications were few.

"He insisted for himself and others on a degree of absoluteness of demonstration which often made him unwilling to publish work which was anything short of complete. Most catholic in his thinking, he never allowed his theories to become for him facts.

"A keen reasoner, a sharp critic, a good loser, and a modest winner, he left a place in the clinic staff of the Medical School which it will be very difficult to fill. He has left the impress of his personality upon all of us, and though he has gone, we shall go forward more steadily and more generously than would have been possible without the inspiration of his example."

Dr. "Van's" domestic life was an underlying double source of happiness and strength. He married Miss Neal Benjamin on Nov. 27th, 1903, and was the father of a son and daughter, all of whom survive him. One of his last joys was the enlargement of very successful photographs of his children. He leaves also two brothers, one a well-known chemist, the other an eminent surgeon in California. The latter was for many years a leading practitioner in Kalamazoo where the writer first formed the acquaintance of Dr. "Van" many years before his interests were turned to roentgenology.

In his home the doctor gave rein to his love of music. He was fond also of general literature and read often far into the night. He was a delightful host and was never seen to better advantage than when relaxed and animated in the society of his friends.

He was a moving spirit of an informal association of Michigan roentgenologists; an association which has no officers, no roster of members, no dues, and no regular time or place of meeting. It was a singularly successful society and its last and most successful meeting was with Dr. "Van" in his famous "shop." He showed everything with the open simplicity and sincerity of the true scientist. This society of his fellows gathered at his home before the funeral to pay him personal tribute of affectionate friendship.

Dr. Van Zwaluwenburg was a valued member of various medical and roentgenological societies, which will join with his Michigan brethren in finding in his life an inspiration to do better scientific work. Particularly THE AMERICAN ROENTGEN RAY SOCIETY has reason to mourn his loss and to honor an active and loyal member who has added luster to the achievements of American roentgenology.

A. W. CRANE.

The following is a list of publications by Dr. Van Zwaluwenburg:

The Diagnostic Value of the Orthodiagram in Heart Disease, *Arch. Int. Med.*, Feb., 1911, vii, 137. (In conjunction with L. F. Warren, M.D.)

Backache, *J. Mich. M. Soc.*, Sept., 1916, xv, 428.

Capillary Circulation, AM. J. ROENTGENOL., Nov., 1916, iii, 532.

Lantern Slide Demonstration of Radiographic Findings, *J. Mich. M. Soc.*, Feb., 1917, xvi, 73.

Roentgenographic Findings of the Month, *J. Mich. M. Soc.*, April, 1917, xvi, 185.

Correlation of Roentgenographic and Surgical Findings, *J. Mich. M. Soc.*, Aug., 1917, xvi, 370.

Foreign Bodies in the Eye, AM. J. ROENTGENOL., Oct., 1917, iv, 512.

Review of Month's Roentgenograms, *J. Mich. M. Soc.*, Jan., 1918, xvii, 28.

Plea for Use of Fluoroscope in Examination of Heart and Great Vessels, AM. J. ROENTGENOL., Jan., 1920, vii, 1.

Tonsillar Route of Infection in Pulmonary Tuberculosis, *Am. Rev. Tuberc.*, Mar., 1921, v, 57. (In conjunction with G. P. Grabfield, M.D.)

Apical Pleuritis and Its Relation to Pulmonary Tuberculosis; Statistical Study of Stereoscopic Roentgenograms of 366 Consecutive Adult Chests, *Am. Rev. Tuberc.*, June, 1921, v, 323.

Pneumoperitoneum of the Pelvis; Gynecological Studies. AM. J. ROENTGENOL., Jan., 1921, viii, 12. (In conjunction with Reuben Peterson, M.D.)

Pelycograph, Its Field and Its Limitations. Read before Am. Rad. Soc., Chicago, Dec. 9, 1921. Manuscript to be submitted to publisher.

Apical Pleuritis: A Statistical Study of Stereoscopic Roentgenograms of 267 Presumably Normal Student Chests. (In conjunction with A. D. Wickett, M.D.) Supplementary to the report entitled "Apical Pleuritis and its Relationship to Pulmonary Tuberculosis." Read before the Trudeau Society of Michigan, Oct. 14, 1921. Manuscript to be submitted.

Experience with Pneumoperitoneal *X*-Ray as an Aid to Gynecological Diagnosis. *Minn. Med.*, July, 1921, iv, 412. (In conjunction with Reuben Peterson, M.D.). The *X*-Ray Diagnosis of Accessory Sinusitis. AM. J. ROENTGENOL., Jan., 1922, ix, 1.

THE CHEMIST IN MEDICINE

THERE has been published lately a report by a committee of the American Chemical Society, whose Chairman is the Editor of the *Journal of Industrial and Engineering Chemistry*, on "The Future Independence and Progress of American Medicine in the Age of Chemistry." The purpose of the report, as stated in the Foreword, is to point out "the need for intensive chemical research, under more favorable conditions than exist today, devoted to the alleviation of human suffering." It deals especially with the need for close cooperation of the physician with the pharmacologist and chemist. In this connection it mentions numerous instances in which progress in medicine was greatly delayed because of lack of such cooperation. Ether, for instance, was discovered in the thirteenth century, but its value as an anesthetic was not recognized until 1846. The report places great emphasis on the dependence of medicine upon the fundamental sciences, chemistry and physics, and recounts in considerable detail the services that these sciences have already rendered to medicine. It also lays out the lines of attack for future work.

One needs only to recall a few of the accomplishments of chemistry to recognize the invaluable aid it has been to the advancement of medicine. Among them are the isolation of pure principles, such as strychnine, quinine, morphine, atropine, cocaine, and many others, from the crude drugs; the creation of synthetics, such as salvarsan; the improvement of drugs so as to remove their toxic or other harmful effects, notably the production of procaine, codeine, and homatropine; the isolation of the active principle of the internal secretions, such as epinephrine and thyroxin.

These are only a few of the accomplishments of chemistry that point out what may be expected when other still unsolved problems are adequately attacked.

To the thoughtful radiologist this report must suggest many possibilities. The need for the thorough investigation of numerous problems in connection with roentgen and radium therapy has long been recognized. For instance, the work of the radiotherapist is greatly hampered by roentgen sickness. The cause of this condition is still unknown. It seems not at all improbable that the solution lies in the field of work of the physiological chemist cooperating with the radiologist. If we were able to answer the questions that arise in connection with roentgen sickness, we might be far on the road to a solution of the problem of the ultimate effect of radiation in the human body. Until we know what changes are produced in the living tissues by the application of the *x*-ray or radium little further rational progress can be expected in the treatment of disease by these agents.

It seems reasonable to believe that the solution must be sought in the changes that take place in the cells and secretions of the living body during and after its subjecti on to radiation, rather than in a study of the end results in tissues removed from the body, however valuable the latter studies may be. An explanation is needed for many of the phenomena known to follow *x*-ray or radium treatment of various conditions. What, for instance, is the reason that we have roentgen sickness in one patient and not in another, apparently given the same dosage in the same region of the body? Why does sickness vary in the same patient at different times? What is the cause of the exceedingly rapid reduction in the white cells in a case of leukemia treated for very short periods over small areas of the body? Why in the same class of cases is the spleen so quickly reduced to normal size? How can one account for the reported cases of Hodgkin's disease in which treatment over one area is followed by disappearance of the enlarged glands in distant areas?

It seems probable that these and numerous other questions could be answered by careful investigation on the part of men properly trained to undertake it.

It will well repay one to read carefully the report mentioned above. It may very well be the introduction to a new era in our specialty and in the progress of medical science.

A. C. Christie.

CORRESPONDENCE

To the Editor:

In the November issue of the Journal there occurs an article entitled "A Preliminary Report on the Effects of Roentgen Rays on Gastric Hyperacidity" by Bryan and Dormody. Its opening paragraph is the following: "In Germany Bruegel and Wilms have been using the roentgen ray with very promising results in cases of duodenal and gastric ulcer with hyperacidity." Because I feel I can add something of interest in this connection, and because it seems unfair to give foreigners the credit for originality when an American had so distinctly antedated them and maintained a steady application and interest in the same thing for years before them, I hope this will be published in the Journal.

Back in the days when the first roentgenograms of the stomach were made by static machines, with the early forms of coils and through its perfected forms, and for years now with the transformer, every case of gastroduodenal ulcer under my care has had from three to ten *x*-ray treatments in the first month or two they were out of bed. In the first edition of my work on "Diseases of the Stomach," published in 1910, four pages of context were devoted to the therapeutic use of *x*-rays in treating gastroduodenal ulcer, the work then being done with a Cole coil. Since that time over 900 cases have been so treated by me in the expectation, as stated then, of "more perfect repair in bringing about a firm cicatrix, favorably influencing the persistent symptoms of hyperacidity, the sensory phenomena of an irritative type, and resulting atony." The reasoning that their use might be beneficial was assumed from the discutient effects on scars of healed carbuncles on the neck, and those of injuries, the stimulation of skin ulcers, keloid, etc., and what was known at the time of the atrophying effects of the *x*-rays on specific cells of highly specialized parenchymatous tissues—the acid or parietal cell of the gastric tubules being one of these.

Roentgenologists generally have agreed that cases of malignant disease after extirpation of the neoplasm should be treated by *x*-rays. There are still some (notably among the surgeons) who doubt this. But it may definitely be stated that no case of gastroduodenal ulcer medically treated should be denied the benefits possible to be brought about from a course of *x*-ray treatments, particularly when hyperacidity is present. In 537 cases carefully selected as those suitable for medical treatment up to two years ago, 87 per cent are cured, and I feel this high percentage was brought about by the employment of the *x*-rays, because many of them were treated before the days of the Sippy diet (when von Leube's diet and that of Lenhartz were employed) and

neutralization of the gastric acidities by giving alkalies steadily was not in vogue.

No case of hyperacidity not due to ulcer should be treated by *x*-rays, because the dietetic and vagus forms are best handled without it, and hyperacidity is so often due to distinct pathology extragastric in the abdomen that it should not be standardized as the treatment of only a symptom. In acida gaster (Reichmann's disease) some bright results have been brought about by the persistent use of the *x*-ray.

The article in question suggests the employment of the *x*-rays during the active treatment of the ulcer. In my experience the best time to do this is after the patient is out of bed during the second month of the beginning of the treatment and after thorough and continued alkalization had been carried out for weeks and was still being continued. Instead of three treatments of from 25 to 35 ma.m. with a 10 in. distance skin target, I employ from 10 to 20 ma.m. with a 15 in. distance, a 3 in. spark-gap, using a 3 mm. aluminum and 5 mm. sole leather, and about 60 kv.—this being modified at times according to skin reactions. Six rayings at weekly intervals are given. At each raying the stomach contains 2 oz. of bismuth subcarbonate. I do not know why this intensifies the good effects from the rayings, but I feel quite sure that it does.

ANTHONY BASSLER, M.D.
21 West Seventy-Fourth Street
New York City

Dec. 23, 1921

RESOLUTION ADOPTED BY THE CENTRAL SECTION

The following resolution was adopted at the meeting of the Central Section:

WHEREAS, Roentgenology has suffered a great loss in the untimely death of Dr. James G. Van Zwaluwenburg of Ann Arbor, Mich., whose achievements gave promise of even more important contributions to science,

WHEREAS, We the members of the American Roentgen Ray Society feel so keenly the loss of our friend and member,

BE IT RESOLVED, That the Secretary engross on the minutes of the Society expressions of our deep sorrow and convey to the family our sincere sympathy in their deep affliction.

ANNOUNCEMENT

The Twenty-Third Annual Meeting of the American Roentgen Ray Society will be held at Los Angeles, September 12–16, 1922. Arrangements have been made with the management of Hotel Ambassador both for the meetings and for the exhibits.

The President-Elect, Dr. Wm. H. Stewart, 222 West Seventy-Ninth Street, New York City, is arranging the program, and it is hoped that especially those members living west of the Mississippi will communicate with him at their earliest convenience to the end of informing him as to the papers they wish to read.

A number of men living on the Atlantic seaboard have expressed a desire to arrange large parties and visit the interesting points en route. Those interested in this matter should communicate with Dr. A. C. Christie, 1621 Connecticut Avenue, N. W., Washington, D. C.

Western members have always attended the Annual Meetings with a regularity that is most commendable, and since this is the first meeting ever held west of the Mississippi, the matter of reciprocity should obtain among all the Eastern members; they should attend the meeting at Los Angeles in numbers as gratifying as if the meeting were in the East, thus giving evidence in no mistakable manner of their appreciation of the high regard in which they hold the Western members.

Subscribers to THE AMERICAN JOURNAL OF ROENTGENOLOGY *visiting New York City, are invited to make the office of* THE JOURNAL (*69 East 59th Street, New York*) *their headquarters. Mail, packages or baggage may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; in this case, kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

BOOK REVIEW

INJURIES AND DISEASES OF THE BONES AND JOINTS, By Frederick H. Baetjer, M.D., and Charles A. Waters, M.D. Containing 350 pages, 332 roentgenograms and 1 line drawing. New York: Paul B. Hoeber. Price $10.

The authors of this volume have written succinctly and with clearness upon a subject which, although a simple one to the roentgenologist in so far as roentgenographic technique is concerned, is one of the most difficult in the matter of diagnostic interpretation. Thus, Chapter IX, dealing with joint lesions in children, and Chapter XI, on the subject of bone tumors, become the important chapters of the book. Chapter IX is well prefaced by another on the epiphyses (Chapter III), a knowledge of which is so essential in the interpretation of infantile and adolescent bone and joint conditions. The authors tend to simplify the subject of joint lesions in children of the first "age-period," usually of difficult interpretation, by dividing it into three groups, based also on subjective age. For purposes of diagnosis by exclusion, these groups are of great help.

In the chapter dealing with bone tumors, Baetjer and Waters utilize their access to a wealth of material which alone gives the highest authoritative value to their writings. Since upon the roentgenologist is so often placed the responsibility of a decision between malignancy of bone and conditions less grave, the value of this chapter to the student is beyond appraisal. Here are found some of the best illustrations of the book, born of invaluable clinical data, as aforesaid.

The authors very wisely judge that a proper consideration of the spine, as the seat of osseous and synovial abnormality, is worthy of a separate chapter. One regrets somewhat the paucity of illustration and description concerning the low lumbar and sacral regional relationships, as presented by the lateral posture of the patient.

Any literary consideration of the nontuberculous joint lesions in the adult revives old moot points with reference to a classification based upon the findings by *x*-rays. In their description of these processes, the authors use the classification now generally accepted, it is believed, by most clinical investigators, and which is well represented both in description and by illustration.

Many newer fields of diagnosis are suggested. For example, the occurrence of bone genesis in traumatic blood-clot, of which, one may be confident, roentgenologists are destined to see more in the future. This probability is brought to mind by the illustration on page 234, although here the ossifying process is said to be subsequent to, and perhaps complicated by, an arthritic condition.

Chapter XIII, describing anomalies, deals chiefly with those of the spine, although certain anomalous conditions of the extremities are well illustrated, as is also a chapter, immediately following, concerning the dystrophies.

This work is presented in a volume so fashioned that it well serves its purpose of clear exposition and description. The quality of the paper has been chosen carefully with reference to the illustrations, some of which could not otherwise be presented with sufficient clarity. The type is large and therefore clear. As a whole, the excellent features of the volume far outweigh the occasional appearance of typographical errors.

PERCY BROWN.

TRANSLATIONS & ABSTRACTS

Studies on Experimental Rickets. 1. McCollum, E. V., Simmonds, Nina; Parsons, H. T.; Shipley, P. G., and Park, E. A. The Production of Rachitis and Similar Diseases in the Rat by Deficient Diets. (*J. Biol. Chem.*, January, 1921, xiv, 333.)

2. Shipley, P. G.; Park, E. A.; McCollum, E. V.; Simmonds, Nina, and Parsons, H. T. The Effect of Cod-Liver Oil Administered to Rats with Experimental Rickets. (*J. Biol. Chem.*, January, 1921, xiv, 343.)

3. Shipley, P. G.; Park, E. A.; McCollum, E. V., and Simmonds, Nina. A Pathological Condition Bearing Fundamental Resemblances to Rickets of the Human Being Resulting from Diets Low in Phosphorus and Fat-Soluble A: The Phosphate Ion in Its Preventions. (*Johns Hopkins Hosp. Bull.*, May, 1921.)

In the first paper the writers describe eleven diets and clearly point out the deficiency in each case. Deformities very similar to those noted in rickets are produced by some. From these investigations the writers believe that rickets might be caused by a deficiency of fat-soluble A or calcium in the food or a disturbance of metabolism of these factors. They apparently sum up their observations by saying that at present it is only possible to say that the etiologic factor is to be found in an improper dietetic regimen.

In the second series of investigations, the animals were fed on a diet low in fat-soluble A and another formula deficient in sodium, calcium and chlorine ions. They soon began to lose weight, became extremely irritable, reacting to any stimulus with violent activity. About forty days later, the rats began to develop xerophthalmia. When it became evident that the animals could live only a few days longer, cod-liver oil in addition was administered to part of them, the others being kept on deficient diets as controls.

The bones of the test and control animals showed no difference except on microscopic examination. No calcium was found in epiphyseal cartilages of those animals not receiving cod-liver oil. Following the administration of cod-liver oil, calcium was deposited in the cartilages even though the intake of calcium in some cases was below normal. The deposit of calcium salts i-s linear and apparently proportional to the length of time the cod-liver oil was given. The calcium is deposited at right angles to the long axis of the shaft of the bone.

The writers believe the cod-liver oil contains some substance or substances which cause calcium to be deposited in rats suffering from experimental rickets in the same manner as it is deposited in the spontaneous healing of rickets in man.

Quick, D. The Combination of Radium and the *X*-Ray in Certain Types of Carcinoma of the Breast. (*Surg., Gynec. and Obst.*, February, 1921.)

The author gives a résumé of the literature on the use of the *x*-ray and of radium in breast cancer. He states that "a review of the literature creates the impression that in general the worker confining his efforts to *x*-rays alone tends to minimize other physical agents, while the radium therapeutist has attempted to cover too large a field with the amount of the element at his disposal."

During the past two years a consistent effort has been made at the Memorial Hospital to combine the two agents. The use of radium over localized recurrent nodules together with *x*-rays over the regional areas has been of distinct advantage; but it is not in these cases that the combination has the most value. In bulky localized tumors, whether recurrences, metastases or primary inoperable growths, he has been able to imbed radium emanation in the tumors so as to give uniform, diffuse radiation, especially in deeper portions of the mass where the *x*-rays have least effect. The use of the buried emanation does not interfere with the use of the *x*-rays, and unless there is some definite contra-indication the *x*-rays are then given in massive doses over the entire local and regional surface. The *x*-ray treatment is as thorough as though no radium were available.

Seventy-eight cases have been treated by the combined method during the past two and a half years. Seven have shown complete regression of the treated areas and have remained clinically free from the disease for periods of three months to over two years. There were twenty-one partial regressions which are still progressing favorably but are not yet clinically free. Many cases were temporarily benefited, among these being twenty-four cases in which there was local improvement but final spread of the disease by distant metastases. Ten cases showed no improvement, but all of these were not only far advanced locally but had widely disseminated metastases. Of the seventy-eight cases fifty-seven were recurrent and twenty-one primary.

Attention is directed to the fact that most cases presenting themselves for treatment by physical agents are the worst types of cancer; treatment must be looked upon as palliative, and where cure is obtained it must be looked upon as a distinct victory. In certain cases of recurrent cancer where the lesions are localized or grouped, and in cases in which there is pleural involvement, he especially advises treatment by radium. Even localized bone lesions should receive radium treatment.

CONCLUSIONS

1. The *x*-ray occupies a place in the treatment of every case of carcinoma of the breast.

2. In certain cases radium may be used to considerable advantage in combination with the *x*-rays.

3. The cases in which radium proves valuable in this combination are mainly:

(*a*) Localized flat recurrences, where surface applications of radium can be made directly over the lesion.

(*b*) Bulky recurrences, where radium emanation can be imbedded directly in the tumor.

(*c*) Axillary involvement, which is always difficult to influence favorably with *x*-rays alone, where radium emanation can be imbedded in the neoplasm or in axillary fat tissue so as to give a diffuse radiation of the axillary space from within.

(*d*) Inoperable primary cases, where imbedded emanation can be utilized to radiate the tumor from within, as well as the axilla, and even supraclavicular space in the same way if necessary.

(*e*) Primary cases refusing operation, where treatment may be carried out much in the same way as in the inoperable primary cases.

4. The combination of radium and *x*-rays may in some instances change an inoperable into an operable case.

He finally points out reason for encouragement in pursuing the study of radium and *x*-ray treatment of mammary cancer, in that such treatment produces a powerful destructive effect on the tumor tissue amounting to local necrosis, the lymphatics may be considered sealed, invisible vagrant cells are incarcerated or destroyed, and all this accomplished without removing the natural barriers which exist against progressive carcinoma. Both types of radiation tend to increase the exudation of lymphocytes and plasma cells and growth of connective tissue around the tumor, and these are the only natural agents of resistance to carcinoma.

Treatment, therefore, is based on sound theory, since it intensifies the natural reaction of the tissues to carcinoma while producing in addition a strong destructive action on the tumor cells.

Hence he feels that the scope of operability of mammary cancer should be reduced. The same principle should be applied as in uterine carcinoma; early cases should be operated and later ones radiated.

A. C. C.

KLEINBERG, S. Traumatic Spondylolisthesis; Report of Two Cases. (*Arch. Surg.*, July, 1921.)

A review of the literature indicates that dislocations of the 5th lumbar vertebra are very rare.

Roentgenographic findings are difficult of interpretation because (1) the 5th lumbar vertebra has a wide range of normal morphologic variation; (2) the forward inclination of the 5th lumbar and sacrum makes it difficult to obtain a clear outline of these bones; (3) overdeveloped transverse processes of last lumbar or 1st sacral segment change or obscure the relation of the 5th lumbar, sacrum and iliac bones, and (4) the proximity of the iliac bones interferes with obtaining a good lateral view.

In studying the lumbosacral region it is necessary to take antero-posterior, lateral and oblique views. Stereoscopic roentgenograms are preferable to flat views.

The cardinal clinical evidences of spondylolisthesis are (1) prominence of the sacrum; (2) a hollow, palpable and frequently visible, immediately above the sacrum; (3) pains in the back and lower extremities; (4) weakness and stiffness of the back; (5) lordosis; (6) forward bending of the trunk; and (7) tenderness of the lumbosacral region.

The combination of these symptoms, especially after trauma, strongly suggests dislocation of the 5th lumbar, but roentgenograms are necessary to demonstrate the lesion.

The writer reports two cases in detail and comments upon them.

The roentgen appearance of the 5th lumbar vertebra in spondylolisthesis is peculiar and pathognomonic. In antero-posterior plates are seen the crescentic outline of the body and the pedicles of the 5th lumbar, its laminæ, spinous process and spinal foramen. The lateral view shows the shadow of the body of the 5th lumbar in front of the sacrum. The writer believes the roentgenographic appearance is characteristic and diagnostic of spondylolisthesis.

A. C. CHRISTIE.

JOHNSON, H. McC. *X*-ray in the Diagnosis of Prostatism. (*Surg., Gynec. & Obst.*, February, 1921, p. 179.)

Under the term "prostatism" the author includes those urinary difficulties of men caused by obstruction at the bladder neck due to glandular enlargement of the prostate, to fibrous changes in it, or to coarctation of the internal orifice of the bladder. The diagnosis is usually based upon the symptoms, information gained by palpation, determination of urethral length and presence of residual urine, and cystoscopy. There are certain conditions that will escape diagnosis by these methods. The cystoscope will not tell the size and shape of diverticula or presence of prostatic calculi, and may overlook an encysted stone. It gives no information of the ureters above the orifices. There are also cases where cystoscopy is contraindicated. The author's purpose is to emphasize the value of cystoscopy and roentgenography when used in conjunction. He employs the following technique: Three *x*-ray exposures are made, the first with the bladder empty, the second with the bladder filled with room air, and the third with the bladder filled with 10 per cent sodium iodide or bromide solution. The object of Plate I is to locate calculi in the prostate and free or encysted calculi in the bladder, and to outline gas in the bowel that may confuse the reading of Plate II. The object of Plate II is to outline an enlarged prostate or other tumefactions. Plate III is made to show diverticula, to show the shape and size of the bladder, and the presence of saccules or dilated patulous ureters.

The author believes that some of the unsatisfactory results of prostatectomy will be eliminated by the routine use of roentgenography in conjunction with cystoscopy.

A. C. C.

RENON and DEGRAIS. Remote Results of the Radium Treatment of Myelogenous Leukemia. (*Bull. Acad. de méd.*, February 15, 1921.)

Since 1910 the writers have treated eight patients with myelogenous leukemia by applications of radium to the spleen. The technique consisted in applications of 2.4 mm. radium element filtered by 2 mm. lead, and 1 cm. of gauze to each square cm. of surface treated, representing 4.848 mgm. hours of radium. The total amount of radium used was 101 mm. of radium element represented by 189 mgm. of radium bromide. The treatment extended over forty-eight hours.

Death has occurred in all eight of the cases treated. The intervals between the treatment and death were as follows: Two years two months; thirteen months; three years, one month; six years, six months; one year; three years, six months; one year, eight months; two months.

The immediate effects were remarkable; the spleen which occupied the entire abdominal cavity diminished rapidly in volume and returned to normal. The number of white cells fell from 320,000 to 7,000; the blood picture was changed; the myelocytes disappeared, and the number of red cells increased; the general condition was improved; the fever disappeared, and the weight increased one kilo or more a week. Two of the patients became pregnant. One of them went to term and the child, living to-day at the age of six years, has shown no evidence of leukemia.

After four to six weeks of treatment the patients are apparently cured. In reality this cure is only apparent, and after two to eighteen months the symptoms of leukemia reappear. The white cell again increase in number and the spleen enlarges. The application of radium is again commenced but the result is not equally good; the number of white cells falls off less rapidly and a longer time is required for the reduction to normal of the spleen. Apparently the patients develop a tolerance to radium; the white cells become apparently radio-resistant and eventually the radium appears to have on influence upon them. The pathogenesis of this resistance has not yet been determined. It may be a simple acquired tolerance of the white cells to radium, analogous to the tolerance of the spirocheta for arsenic, or it may be that the fibrous transformation of the leukemic spleen under the action of radium has some effect upon the myelocytes. Recurrences take place more quickly in patients who have been previously treated by the *x*-rays than in those previously treated by radium.

The writers recommend that the spleen be treated by radium in large doses and that the long bones receive radiation with the *x*-ray.

LOWELL S. GOIN.

HIRSCH, O. The Radium Therapy of Hypophyseal Tumors. (*Arcb. f. Laryngol. u. Rbinol.*, 1921, xxiv, No. 1).

Because of rather uncertain results obtained by surgery in hypophyseal tumors, Hirsch has been led to attempt their radium treatment. His early results were bad, but by progressively increasing the dose of radium he was able after seven failures to obtain some very satisfactory results. His statistics include 28 cases, about one-half of which are still under treatment.

In his hands radium therapy has habitually been preceded by surgical intervention. A cure may be effected surgically in cases of cystic tumor, but in the case of acromegaly without visual disturbances, or a hypophyseal adenoma, radium treatment is indicated.

The first application of radium is not made until the operative wound is healed in order to avoid all risk of infection.

The technique consists in the use of 20 mgm. of radium filtered by from ½ to 1 mm. of brass and placed in contact with the tumor for twelve hours. At times one treatment is sufficient to excite a reaction, but more often a number of applications are required.

The action of radium, however, varies with each case. It may manifest itself by an improvement in the visual disturbance and the acromegalic hypertrophies, by an improvement in the trophic disturbances, or by a return of menstruation. In general, one may say that the results are better when the hypophyseal tumors are accompanied by acromegaly and symptoms of hypersecretion then when accompanied by ocular disturbances and the phenomena of hypersecretion.

In two cases the author observed accidents which might be imputed to the radium therapy. The first was a man, twenty-four years old, with acromegaly and marked visual disturbances. He received two applications of radium, with a five weeks' interval, with much improvement; but at the end of six weeks a severe glycosuria appeared and the patient promptly died in coma. It is possible that because of his youth this patient was particularly susceptible to the action of radium. In the second case a fatal hemorrhage occurred one year after a series of fourteen applications of radium. No autopsy was had and the cause of death has not been satisfactorily explained.

L. S. G.

KIRKLIN, B. R. A Plea for Routine *X*-Ray Examination of the Gall-Bladder Region in Every Chronic Abdomen. (*J. Radiol.*, Vol. II, No. 4.)

One should not limit one's efforts to the demonstration of the gall-stones, which are usually of secondary importance, but should attempt a demonstration of the pathological gall-bladder. As to technique, the writer administers a cathartic on several evenings preceding the examination and examines the fasting patient. From three to six exposures of the gall-bladder region, including the area between the tenth rib and the crest of the ilium, are made, varying pentration, time, etc., but with constant time factor in development, thus obtaining plates of varying densities. A barium meal, is then administered and search is made for secondary signs of gall-bladder disease. Any shadow on the *x*-ray plate which is interpreted as being gall-bladder shadow, represents, in the writer's opinion, a pathological gall-bladder. The secondary signs are:

1. Hepato-fixation of the stomach, the pyloric region being drawn upward and to the right.

2. Characteristic deformity of the first portion of the duodenum and possibly the second portion, due to adhesions.

3. Outlining of enlarged gall-bladder by pressure on the duodenum or the antrum.

4. A definite small area of pain on pressure accurately localized on the outer side of the shadow of the duodenum, usually accompanied by a delay in the duodenum.

5. Pressure of Riedel's lobe of the liver when demonstrable, following gas distension of the stomach and colon.

6. Hypermotility of the stomach and unusual visibility of duodenum.

The writer reports 128 cases of gall-bladder disease demonstrated by *x*-ray methods, in 92 per cent of which diagnosis was verified by operation.

L. S. G.

ROSENFELD, ARTHUR S. Idiopathic Purpura with Unusual Features. (*Arch. Int. Med.*, Vol. XXVII, No. 4.)

Purpura is an extremely rare condition, considered by many as being merely a manifestation of some other disease, but there are familiar tendencies to the purpuric diathesis which rather speak for the disease as a definite entity. The writer reports two cases occurring in brothers showing constant bone changes as seen in the radiograms of the knees and elbows. These changes consist in an enlargement of the piphyses of the bones with well defined areas of rarefaction, slight roughening of the articular surfaces as in osteo-arthritis and, in the knee joint, a definite thickening of the soft structures of joint, such as one sees in bloody joint effusions.

Our knowledge of pathology of this condition has been gained by *x*-ray study, operation, and by a few autopsies in cases that have succumbed to intercurrent conditions. The hemorrhages occur most often in the knee-joint. Following a slight blow, or often spontaneously, there develop signs of acute joint affection with effusion. If the effusion persists it goes on to inflammation with a fibrinous effusion, as in the ordinary tuberculous "white

swelling." This condition is simulated almost perfectly, but the *x*-ray will show that the bone is not involved, and that the process is confined to the soft parts of the joint. In this stage synovial villæ are present as well as defects in the joint cartilages. The *x*-ray shows changes in the epiphyseal lines, which are zig-zag and have a worm-eaten appearance. The condylar outlines are not sharp. There is bone atrophy with rarefaction of the condyles. If hemorrhages occur in the joint often enough there is a third stage in which there are contractures, bone and joint changes, thickening of the periarticular structures and even ankylosis.

L. S. G.

INGRAHAM, C. B. Impressions Gained from the Use of Radium During the Past Year. (*Colorado Med.*, Vol. XVIII, No. 4.)

The writer's results in the treatment of superficial epitheliomata have been universally good. Three cases of cancer of the face, two of which involved the antrum, and one of the cheek inside the mouth, have been disappointing. Of three cases of cancer of the tongue, two died and one made gratifying improvement. Two cases of cancer of the esophagus died. A cancer of vulva remained well for seven months when the patient died of pneumonia without any sign of recurrence. In two cases of sarcoma, one arising from ethmoid and one from frontal, gratifying immediate results were obtained. Much improvement followed the radium treatment of four cases of vernal conjunctivitis. Marked improvement followed the treatment of eight cases of carcinoma of the cervix. The writer expresses satisfaction with results following radium treatment of the uterine fibroids.

L. S. G.

ASHBURY, HOWARD E., and GOLDSTEIN, ALBERT E. The Combined Examination of the Urinary Tract by the Urologist and the Roentgenologist. (*South. M. J.*, September, 1921.)

The essay is based upon the study of 250 cases that have come to the Urological Clinic of the Hebrew Hospital of Baltimore during the past two years, in which a combined study was possible; it outlines the method of procedure and basis of interpretation, which save time and the annoyance of repeated cystoscopics, and which make possible a prompt and accurate visualization of existing pathology. The deductions offer a fair example of the limitations of the two methods individually and give a practical idea of the value of the combined study in so far as the reduction of the percentage of failures and the large percentage of proven correct diagnoses are concerned.

In all the cases studied, plain roentgenograms were made of the entire urinary tract, and then the cases were studied urologically, using all recognized methods of procedure.

Capacity in all cases was first determined with sterile water or salt solution. The administration into the renal pelvis of opaque solutions should be performed by competent urologists, who may use either the syringe or the gravity method, the syringe being used in these cases.

The plain roentgenograms in urological cases necessarily divide themselves into those giving positive findings and those giving no evidence of disease. The latter far exceed the former, and include a large percentage of non-radiable calculi, of uric acid composition. These are located principally in the bladder.

Of the 250 cases studied, 152, or 60.8 per cent, demonstrated pathological lesions in the urinary tract, and 98, or 39.2 per cent, demonstrated no urological lesions. The plain roentgenograms gave evidence of disease in 50 or 32.7 per cent.

Out of a total of 46 urinary calculi, 41, or 89.1 per cent, gave evidence on the plain plate; 5 cases in which no evidence of shadow was seen on the plain plate were vesical calculi and were diagnosed by cystoscopy and cystography. It is interesting to note that all the ureteral calculi that were diagnosed gave a definite shadow in the plain plates, which is contrary to the published statistics.

One hundred and forty-eight cases, or 97.3 per cent, gave evidence of disease by the urological method; 104 or 61.7 per cent, were positive from the urological findings, and 44, or 38.3 per cent, were doubtful. The 44 doubtful cases were finally diagnosed by the combined method, leaving only 4 cases undiagnosed.

The entire 152 cases which presented pathology were verified by an operation of some character. In the 4 undiagnosed cases exploratory operations were advised, and pathological conditions were demonstrated at the operation.

CONCLUSIONS

1. By the combined method of examination our results show only 1.6 per cent of failures.
2. Urological lesions were demonstrated frequently by aid of the *x*-ray where they were doubtful in the two examinations individually.
3. In over 50 per cent of the cases in which the plain roentgenogram was negative pathological conditions were found by the combined method of examination.

4. The plain *x*-ray findings should in all cases be verified by the urologist before a conclusive diagnosis is given.

5. The combined method is the ideal procedure for the diagnosis of urological conditions.

AUER, JOHN, and WITHERBEE, WILLIAM D. Studies on Decreasing the Reaction of Normal Skin to Destructive Doses of *X*-Rays by Pharmacological Means, and on the Mechanism Involved. (*J. Exper. M.*, June, 1921, Vol. xxxiii, No. 6.)

When a fixed area of the ears of rabbits is subjected to the action of a standard destructive dose of *x*-rays (30 skin units), the type of reaction resulting depends upon the previous treatment of the rabbit. (1) In normal rabbits a mild acute inflammation develops in the *x*-rayed area which leads at once to a perforating gangrene within an average of fifteen days. (2) If rabbits are *x*-rayed and about two weeks later injected with horse serum for the first time, a mild acute inflammation appears which heals for a time; then a second, subacute inflammation sets in which leads to a perforating gangrene. The average time of the process from the first inflammation to gangrene is thirty-two days. (3) If rabbits are sensitized with horse serum and ten days later are exposed locally to the standard dose of *x*-rays, the ensuing ear reaction is either similar to the second reaction described above, except that it may last up to 110 days, or the first inflammation leads to a healing which may be apparently permanent (340+ days). (4) If rabbits are first sensitized with horse serum, exposed locally to the standard dose of *x*-rays ten days later, and thirteen days after the *x*-ray treatment reinjected with horse serum, the reaction of the *x*-rayed area of the ears is in general similar to the second reaction described above (inflammation-healing—inflammation-gangrene). The average time of the whole process is about forty-two days.

On the basis of the general hypothesis that an anaphylactic reaction is initiated in the body when the specific antibody meets its antigen, and that both antibody and antigen are rendered more or less functionally inert by their interaction, the following inferences may be drawn from our experimental results. (1) The protection from the effects of a standard destructive dose of *x*-rays which a previous sensitization confers is referable to the presence of anaphylactic antibodies in the *x*-rayed area. (2) This protection is largely due to the anaphylactic antibodies which are anchored in the *x*-rayed area, and not to those which are free in the circulation. (3) An anaphylactic reaction renders the anchored anaphylactic antibodies largely impotent as protective factors against the standard destructive *x*-ray dose, even though sensitization preceded exposure to the *x*-rays. (4) An area treated with the standard destructive dose of *x*-rays is unable to produce or to anchor a sufficient amount of anaphylactic antibodies for protection from necrosis, when the *x*-ray treatment precedes the sensitization, or when the locally anchored anaphylactic antibodies are rendered functionally inactive by a general anaphylactic reaction.

It is possible that the procedure of increasing the resistance of the skin to a destructive dose of *x*-rays by means of a previous sensitization with protein may be applicable in the treatment of certain types of inoperable disease, when it is important to use massive doses of *x*-rays.

Animals which have been sensitized, or sensitized and reinjected with any undenatured alien protein, should not be reemployed as normal controls in any investigation unless trial has shown that these proteinized animals react quantitatively and qualitatively like normal animals.

The presence of an abnormal reactor in a group of supposedly normal animals may be an indication of a previous proteinization.

MURPHY, JAS. B., WITHERBEE, WM. D., CRAIG, STUART L., HUSSEY, RAYMOND G., and STRUM, ERNEST. Effects of Small Doses of *X*-Rays on Hypertrophied Tonsils and Other Lymphoid Structures of the Nasopharynx. (*J. Exper. M.*, June, 1921, Vol. xxxiii, No. 6.)

The small series of cases reported here shows the possibility of materially reducing the lymphoid deposits of the nasopharynx by comparatively small doses of *x*-rays. Animal experiments had shown that it is possible with *x*-rays to induce any degree of atrophy of the lymphoid tissue without damaging other tissues. In the series of treated individuals, in all but three or four instances one treatment gave an entirely satisfactory result. In two refractory cases a second treatment was followed by the desired degree of atrophy and a clearing up of the pathological condition. It is most probable that the other few individuals who did not respond to the one treatment would have yielded on further exposure to *x*-rays, but unfortunately the observations were discontinued before this point could be determined.

The degree of atrophy to be aimed at is a

matter that experience will decide. If a reduction below the normal size and the clearing up of obvious pathological states is sufficient, as has been indicated in the majority of the cases treated and observed by us, there seems to be no reason for carrying the treatment beyond this point. In view, however, of the mild nature of the treatment recommended it appears entirely safe to repeat it at suitable intervals so as to secure almost any degree of atrophy that may be desired.

The original idea in taking up this work was that the excess of lymphoid tissue interfered with the clearing up of local infections of the pharynx. It seems probable, however, that the disappearance of infection of the tonsils and change in bacteriological flora after *x*-ray treatment are due to the opening up and proper drainage of the crypts which follow atrophy, rather than the actual removal of the excess lymphoid tissue.

Tonsils which have been exposed to the *x*-rays and not sufficiently reduced in size would in all probability be as amenable to surgical removal as before the *x*-ray treatment, for we have never seen any evidence of fibrosis in the lymphoid organs of animals after similar treatment.

Forty-six individuals with tonsils both hypertrophied and otherwise pathologically altered and some of whom had in addition adenoid masses and lymphoid deposits posterior to the pillars of the fauces, were given exposures to *x*-rays. In all but four cases the treatment was followed by marked atrophy of the tonsils and the other lymphoid deposits, attended by an opening and drainage of the tonsillar crypts. As this process progressed the previously enlarged tonsils assumed a smooth and normal appearance and the hemolytic bacteria—streptococci and staphylococci chiefly—which were often present in the affected tonsil, disappeared usually within four weeks of the treatment.

SPINELLI (Naples). Contributions to the Radium-Roentgenological Treatment of Cancer of the Uterus.

The author gives his cancer patients the benefit of special service to determine the organic resistance and to stabilize the general condition. Thus he tests the blood and the renal functions. In order to increase the resistance he treats the patients with neosalvarsan and colloid metals. He injects mesothorium solutions into the primary tumor and metastases whenever this is possible. He then uses both radium and *x*-rays.

Radium is indicated in precancerous lesions and localized primary growths either in the cervix or corpus uteri; the *x*-rays are indicated in infiltration of the parametria and should be ultra-intensive.

The author also believes that diathermy is valuable for increasing organic resistance, or, better, that it makes the cancer cell more sensitive to the action of the rays.

FISCHER, JOH. FRED. (Copenhagen). The Roentgen Treatment of Morbus Basedowii. (*Acta Radiologica*, Sept. 20, 1921, Vol. 1, No. 2.)

Among 490 patients treated for goiter there were eleven men. The material at hand is divided into two parts, viz., those treated at hospitals, and private out-patients, the majority of the former belonging to the working classes, and the latter for the most part to the well-to-do classes.

The prognosis varies within these two classes; it is most favorable for the well-to-do, because the working-class patients are not, as a rule, able to take the care so necessary in this disease. In four-fifths of the cases a positive result was attained, with complete or partial cessation of symptoms. Recurrences occurred principally among the poorer patients; on the whole, the duration of the results attained was satisfactory. Nervousness and pulse rate decreased, increase in weight was usual, in several cases the increase was about 20 kilo. Perspiration and diarrhea disappeared, likewise glycosuria which was observed in 3 per cent of patients. In 25 per cent the pulse had become normal and in 50 per cent it had decreased considerably in frequency. Exophthalmia in several cases had disappeared.

Serious complications are precluded if the administration of roentgen rays is carried out with care, so that in the severe cases one should not run the risk of roentgen intoxication.

The usual dose has been 10 H. with 3 mm. aluminum filters in 4 fields, the one on thymus.

HEYERDAHL, S. A. (Kristiania). Radium Treatment of Changes in the Thyroid Gland. (*Acta Radiologica*, Sept. 20, 1921, Vol. 1, No. 2.)

In the Radium Institute of the Rikshospital twenty-four cases of goiter have been treated with radium since 1913.

The eight cases of plain goiter have been partly serious cases. In all of them the goiter has diminished during radium treatment. In two cases almost complete cure was achieved. In six cases there was a change for the better.

Of the eight cases of toxic goiter one case was almost cured, five cases improved and

two not improved. The radium treatment had an absolutely favorable influence on the general state of health and on the nervous symptoms. The sleep and appetite improved, the weight increased and the state of mind became more composed. The pulse calmed and the size of the goiter diminished. The exophthalmos was least influenced.

Of the eight cases of struma maligna five were temporarily improved; in three cases there were no good effects on the tumor.

KLASON, T. (Stockholm). Pericarditis Calculosa and Heart Calcifications. (*Acta Radiologica*, Sept. 20, 1921, Vol. 1, No. 2.)

The author calls attention to the fact that pericardiac calcifications have a tendency to be situated on the lower surface of the heart. He is of the opinion that these calcifications are often split, having the shape of a net, and form a ring around the heart below the sulcus coronarius. One calcification inside the annulus fibrosus was sharply limited and had no rays. As to the diagnosis, the most important thing is fluoroscopy with a sufficiently hard tube. The seat of the calcifications along the sulcus coronarius is the cause of the often unimportant symptoms of deranged circulation.

SINDING-LARSEN, CHR. M. F. (Kristiania). A Hitherto Unknown Affection of the Patella in Children. (*Acta Radiologica*, Sept. 20, 1921, Vol. 1, No. 2.)

The author gives the records and roentgenograms of two otherwise healthy girls, aged ten and eleven years, who after overstraining themselves by dancing, jumping, etc., had complained of pain *in their knees*. When seen by the author the affection in both cases was *clinically unilateral*, located in one of the patellae, which was painful on percussion; only in one of the cases were the soft parts above and below the patella slightly inflamed (swollen).

Roentgen plates of the knees taken in profile showed the anterior or lower outlines of the painful patellae hazy, with abnormal calcium salts—or bone shadows in the soft parts (periosteum?) along and below them, *the author thinks as a result of periostitis or epiphysitis through overstrain*. The tibia in one of the cases showed a mild form of Schlatter's disease.

The roentgenograms of the apparently healthy knee in both cases showed similar abnormalities of the patella in a less degree.

One case had a plaster of Paris bandage for six weeks; the other was simply ordered to keep quiet.

After about one-third of a year the patellae of both cases were quite all right, and their roentgenograms normal.

ABRAHAMSEN, H. (Copenhagen). Koehler's Disease, Especially with a View to Its Pathogeny. (*Acta Radiologica*, Sept. 20, 1921, Vol. 1, No. 2.)

It concerns a seven-year-old boy who drags his right leg somewhat. On objective examination only an atrophy of the lower leg was found. The roentgen examination made on April 22, 1920, showed that the os naviculare was missing. It may be imagined to be the "preliminary stage" of Koehler's disease. He was treated with thyroidin for a couple of months or so, and the roentgenogram showed that the os naviculare had grown considerably and was 7 mm. in diameter. The contours are irregular and the picture is typical of Koehler's disease. One month later the diameter was 9 mm.

This case seems to speak in favor of Koehler's view, namely, that the disease is due to an anomaly in the development. One cannot divest one's mind of the idea that the thyroidin preparation has played a certain part in the development of the bone.

STROM, S. (Stockholm). On the Roentgen Diagnostics of Changes in the Appendix and Cecum. (*Acta Radiologica*, Sept. 20, 1921, Vol. 1, No. 2.)

A normal appendix can be proved at the roentgen examination just as well as a pathological one.

The pathologic-anatomical changes in chronic appendicitis are of several different kinds, and the roentgen picture is therefore not uniform, but shows different combinations of anatomical and functional changes.

In the roentgen examination of the appendix one should attach special importance to pronounced changes in its form, such as stenoses and kinks together with adhesions. Hereto may be added, as pathological symptoms, spasm, hypermotility and tenderness on pressure. Retention in the appendix after the emptying of the cecum should be interpreted as a pathological symptom only with extreme caution.

Incompetency in the ileocecal valve, established by examination with enema, is of no value as a symptom of changes due to chronic appendicitis and probably not as a pathological symptom at all.